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## CONTENTS

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### **A CASE REPORT OF GAS GANGRENE CAUSED BY RARE TYPE OF CLOSTRIDIUM – CLOSTRIDIUM LIMOSUM**

*Velizar Hadzhiminev, Krasi Kalacheva*.....69-73

### **BONE AND SOFT TISSUE MORPHOLOGICAL MARKERS IN MOUTH-BREATHING CHILDREN USED BY ORTHODONTISTS AND OTOLARYNGOLOGISTS**

*Mirela Georgieva, Emanuel Emilianov*.....75-81

### **IMPACT OF INOSITOL SUPPLEMENTATION ON ENDOCRINE FUNCTION, MENTAL HEALTH AND CARDIOVASCULAR RISK FACTORS: A CLINICAL STUDY**

*Hajrudin Spahović, Lana Lekić*.....83-86

### **ASSESSMENT OF SENSORY PROCESSING IN CHILDREN WITH AUTISM SPECTRUM DISORDER USING THE SHORT SENSORY PROFILE: A STUDY OF 60 PARTICIPANTS**

*Ivan Mihaylov*.....87-91

### **THE IMPACT OF ULTRA-PROCESSED FOODS ON THE GLOBAL OBESITY EPIDEMIC**

*Marija Dimitrovska*.....93-96

### **ANATOMICAL AND MORPHOLOGICAL VARIATIONS OF THE BASILAR ARTERY ASSOCIATED WITH CEREBRAL CIRCULATION CHANGES**

*Gazmend Zylbeari, Sadi Bexheti, Tose Krstev*.....99-102

# A CASE REPORT OF GAS GANGRENE CAUSED BY RARE TYPE OF CLOSTRIDIUM – CLOSTRIDIUM LIMOSUM

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**Abstract:** Introduction: Gas gangrene (GG) is a necrotizing soft tissue infection with extremely poor outcome. It is caused predominantly by Clostridium perfringens and is related with compromised immunity. Case report: We present a clinical case of 38 years old male with metastatic oesophageal cancer who developed gas gangrene as a site infection in the area of port-a-cath used for chemotherapy. Unfortunately, the patient died sooner after the admission and the performed surgery. Bacterial wound culture revealed Clostridium limosum – unusual type of Clostridium bacteria as a cause of the infection. Conclusion: Gas gangrene could be caused by different types of Clostridium Species. It has very high mortality rate even with timely treatment.

**Keywords:** gas gangrene, soft tissue infection, clostridium limosum

**Field:** Medical Science and Health

## 1. INTRODUCTION

Gas gangrene, also known as clostridial myonecrosis, refers to a serious muscle infection caused by toxin-producing clostridial bacteria, and the two terms are often used synonymously. The first clostridial species, Clostridium butyricum, was identified by Louis Pasteur in 1861. In 1892, Welch, Nuttall, and colleagues later isolated a gram-positive anaerobic bacillus from gangrenous wounds. (Chapnick & Abter, 1996)

The condition became especially prominent during wartime because of its high incidence in combat-related injuries, while cases among civilians were uncommon. During World War I, gas gangrene was reported in about 6% of open fractures and 1% of all open wounds. In subsequent conflicts, its incidence progressively decreased, dropping to 0.7% in World War II, 0.2% during the Korean War, and as low as 0.002% in the Vietnam War.

(Gawande, 2004; Buboltz & Murphy-Lavoie, 2023)

Clostridia are widespread in the environment and are particularly abundant in soil, especially in cultivated areas. Their presence in soil significantly contributes to the development of gas gangrene following traumatic injuries. In civilian populations, the disease is more frequently encountered, with approximately 3,000 cases reported each year. Gas gangrene can be classified as post-traumatic, post-operative, or spontaneous. Traumatic cases account for about 70% of all infections, with Clostridium perfringens causing roughly 80% of these. Other causative species, in decreasing frequency, include C. novyi, C. septicum, C. histolyticum, C. bifermentans, C. fallax, and C. limosum. (Buttolph & Sapra, 2025)

Gas gangrene is a highly life-threatening condition associated with substantial mortality. Although recent reports indicate an average mortality rate of about 25%, the risk of death approaches 100% in spontaneous cases or when treatment is delayed.

Effective treatment relies on prompt, aggressive surgical debridement combined with the early administration of appropriate antibiotics. (Sharma, Tanveer & Dixit, 2022; Wang & Dai, 2013; De & Bhesania, 2003)

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## 2. CASE PRESENTATION

A 37-years old male patient with previous medical history for esophageal cancer with mediastinal and liver metastases (T3N2M1) was admitted to the Department of General surgery of the University Hospital "St. George" in critical condition on 7th of March in the morning.

On March 6th 2024:

- at 11:30 in the morning he underwent neoadjuvant chemotherapy through a right port-a-cath in hospital in Sofia and later in the afternoon discharged. He travelled back to his hometown.

- at 21:00 in the evening the patients complained of pain in the right shoulder and became febrile.

On March 7th 2024:

- at 08:00 am his right upper limb became edematous and the skin colour changed to dark-blue. His general condition worsened.

- at 11:30 he was admitted in our surgical department. His vitals during admission were following: Blood pressure - 80/40 mm Hg; Heart rate – 130 bt./min.; Respiratory rate: 24; Glasgow Coma Scale – 6 pts.(soporose). Patient's local status revealed skin necrosis with bullae and crepitations engaging the right upper limb, right shoulder and torso – gas gangrene. (Figure 1).

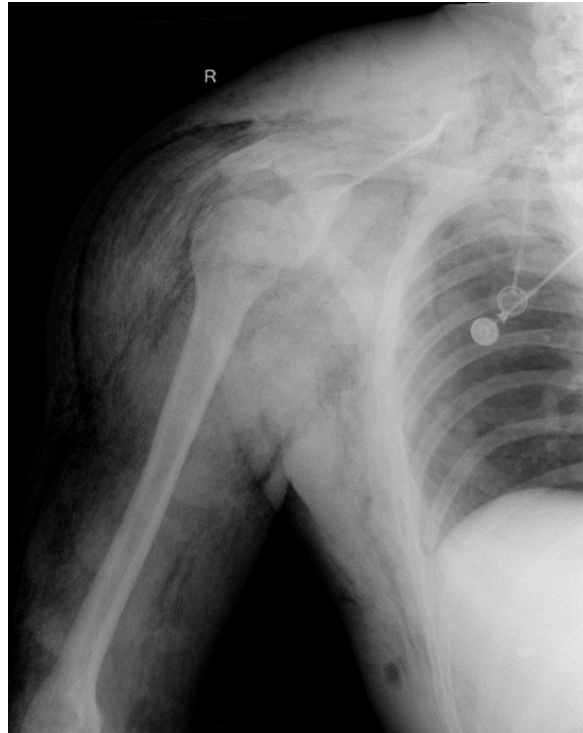
Figure 1. Gas gangrene - skin necrosis with bullae



Source: Authors' research

Relevant laboratory findings at the time of hospitalization were following: HGB – 121 g/l; RBC – 4.43; WBC – 1.72; PLT – 226; glucose – 2.3 mmol/l; CRP – 34 mg/l; t. protein – 14.1 g/l; CK – 4215 U/L; PT – 21.6%. X-ray of the chest and the right arm revealed air-collection in the soft tissues with diffuse subcutaneous emphysema (Figure 2).

Figure 2. X-ray of right arm with diffuse subcutaneous emphysema



Source: Authors' research

- at 11:40 the patient was intubated and immediate fluid resuscitation and broad-spectrum antibiotic therapy were initiated.
- at 11:45 damage control surgery with long and wide incisions with extensive debridement were performed and the intermuscular spaces of the right upper limb and torso were opened. (Figure 3)

Figure 3. Gas gangrene: damage control surgery – wide incisions with extensive wound debridement



Source: Authors' research

- at 11:55 the patient experienced cardiac arrest. Cardio-pulmonary resuscitation was performed according to the Advanced Cardiac Life Support protocol.
- at 12:35 exitus letalis was registered

A rare type of *Clostridium* species was isolated from the patient's wound – *Clostridium limosum*. Before hospitalization, the patients and his relatives provided their written informed consent for the further treatment and study participation.

### 3. DISCUSSION

*Clostridium limosum* is an anaerobic, Gram-positive, rod-shaped bacterium typically found in soil. It can cause infections in a broad range of hosts, including humans, cattle, alligators, chickens, dogs, and farmed mink. The organism has also been identified in home-cured meats and in diverse human clinical samples, such as blood, peritoneal and pleural fluids, soft tissue, and lung tissue. Previous research indicates that *C. limosum* is susceptible to several antibiotics, including chloramphenicol, erythromycin, penicillin G, clindamycin, and tetracycline. Despite its broad environmental presence, human infections caused by *C. limosum* are extremely rare, with only four cases previously reported in the English-language medical literature. These included two cases of prosthetic heart valve infection and two cases involving infected sacral pressure ulcers. In three of these reports, the organism was identified as part of a polymicrobial infection. (Lok Yung, 2019; Cato & Smith, 1970; Felner & Dowell, 1970; Gohari & McClane, 2021; Gordon & Axelrod, 1985; Shibuya & Takayasu, 1994)

Virulence factors attributed to *C. limosum* include collagenase, lecithinase, and toxins that target monocytes and macrophages. Although human infections are rare, they usually arise as part of polymicrobial infections. The current case represents the fifth reported human infection caused by *C. limosum* and only the second in which it was identified as the sole pathogen. Among the four previously documented cases, two were cases of prosthetic valve endocarditis, where *Pseudallescheria boydii* was also recovered from the prosthetic material. (Gordon & Axelrod, 1985) The remaining two cases concerned sacral pressure ulcers that progressed to gas gangrene; *C. limosum* was one of several pathogens identified, and both patients ultimately died. (Shibuya & Takayasu, 1994; Wu & Qu, 2024) Additionally, one study reported *C. limosum* among isolates obtained from 87 patients with skin and soft-tissue infections, identifying the organism in two cases. However, detailed information regarding these patients, including whether the infections were monomicrobial or polymicrobial, as well as treatment and outcomes, was not provided. (Gohari & McClane, 2021)

The clinical presentation of spontaneous *Clostridium limosum* infection is often vague and nonspecific, with manifestations that may include sepsis, abscess formation, soft tissue infection, endocarditis, neutropenic enterocolitis, or bacteremia. Spontaneous clostridial gas gangrene typically has an insidious onset, with localized pain at the involved site being one of the earliest symptoms. Classic signs, including crepitus and the development of bullae, usually emerge later in the course of the disease. Once systemic toxicity develops, rapid clinical deterioration may occur, frequently progressing to septic shock and death. The clinical spectrum of clostridial bacteremia is broad, ranging from asymptomatic cases with positive blood cultures to fulminant shock and fatal outcomes. Gas gangrene is primarily diagnosed based on clinical findings, although imaging studies demonstrating the presence of gas within affected tissues can aid in diagnosis. Definitive confirmation is achieved through microbiological culture. (Chapnick & Abter, 1996; Kousa & Millner, 2020) When gas gangrene is suspected, treatment must be initiated immediately, including early antibiotic therapy and urgent surgical management. Spontaneous infections caused by *C. limosum* are associated with extremely high mortality, with survival reported in only one of the five documented cases. (Lok Yung, 2019)

It is probable that our patient contracted *Clostridium limosum* during a portacath procedure performed the day before his emergency hospital admission, while undergoing chemotherapy. Possible contamination by healthcare personnel should also be considered. The infection likely entered through the portacath site in the right subclavian region, as the initial symptoms - pain, redness, and swelling - originated there and then spread to the right shoulder, arm, and torso. It is also likely that the symptoms observed upon hospital admission were signs of septic shock and coagulopathy, which ultimately contributed to the fatal outcome.

#### 4. CONCLUSION

We report a clinical case of gas gangrene caused by the rare *Clostridium* species, *Clostridium limosum*. This type of infection is typically linked to immunocompromised conditions and underlying malignancies, and it has the potential to affect multiple organ systems. Despite prompt medical intervention, gas gangrene remains a highly lethal condition with a significantly high mortality rate.

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# BONE AND SOFT TISSUE MORPHOLOGICAL MARKERS IN MOUTH-BREATHING CHILDREN USED BY ORTHODONTISTS AND OTOLARYNGOLOGISTS

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**Abstract:** Several morphological markers are observed in children with nasal breathing disorders. They are often diagnosed during orthodontic analysis in relation to concomitant orthodontic deformities. Mouth breathing leads to muscle activity changes affecting the oral functions - mastication, swallowing and phonation. The muscles involved in the mouth breathing contract at the same time as the muscles involved in the other oral functions and affect each other.

Aim of the research was to describe a method for simultaneously identifying bone and soft tissue changes in the orofacial region.

In orthodontics, a large field of view (FOV) CBCT covering the entire skull, is obtained. A 3D imaging software is used to evaluate the changes in the bones, the soft tissues and the upper airways.

A single CBCT scan can establish the three-dimensional development of the maxilla and mandible, the level of bone insufficiency, TMJ disorders (TMDs), facial asymmetries, assess bone maturation and determine bone age. It gives the ability to objectively measure airway volume, identify areas of upper airway obstruction, superimpose images of anatomic structures and to track soft tissue changes. It is used in the planning of orthognathic reconstructions and in the digital designing of surgery guides or orthodontic appliances.

Evaluation of Consecutive CBCTs (before and after treatment with maxillary expander) of patients with upper airway obstructions, can be done by both an orthodontist and an otorhinolaryngologist. They can establish the changes in the widths of the bony palate, the maxilla and the interzygomatic space. Additionally, the increase in volume of the nasal, nasopharyngeal and pharyngeal airways can be measured and the areas of obstruction can be identified.

**Keywords:** *CBCT imaging, mouth breathing, orthodontic deformation, rapid maxillary expansion*

**Field:** Medical Sciences and Health

## 1. INTRODUCTION

The nose and the mouth represent two parallel pathways through which air enters and exits the human body. The predominance of one of these pathways is influenced by functional disorders, disease development in children, or by continuing deleterious oral habits. Mouth breathing is one of the most common deleterious oral habits in children and is often accompanied by sleep disordered breathing. Transition to mouth breathing in growing children may arise from upper airways obstructions. Mouth breathing has been shown to lead to various skeletal changes. (Lin et al., 2022) These changes have impact on the soft tissue development and function. Nasal breathing, in conjunction with other oral functions of the craniofacial complex (mastication, swallowing, phonation), influences the direction and magnitude of the craniofacial growth. (Grippaudo et al., 2016; Zheng et al., 2020)

The etiology of mouth breathing is multifactorial. The most common anatomical structure alterations that are responsible for this condition include narrow airways, adenoid hypertrophy, nasal septum deviation, nasal polyps, respiratory allergies, turbinate hypertrophy and poor sleep posture. In addition, establishing the etiology of mouth breathing also helps in predicting the changes in the maxillofacial growth. (Iwasaki et al., 2017)

Mouth breathing leads to functional alteration including changes in tongue position, oral and perioral muscle tonus, changes in head and neck posture, which facilitates mouth breathing by increasing the airflow through the upper airways. (Bakor et al., 2011) In normal breathing patterns the lips are in contact, the tongue is positioned in contact with the palate and the lingual side of upper anterior teeth. Balanced muscle strength from the inner muscle group (the tongue) and the outer muscle group (the lips and cheeks) is critical for the development of a normal upper dental arch. Mouth breathing immediately disrupts this balance. Children with mouth breathing develop upper dental arch (maxillary) compression, which is accompanied by a crossbite in the posterior teeth segments. The mandible is in backwards

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rotation and the distal teeth, due to the lack of occlusal contacts from the permanently open mouth, show a tendency to over erupt, increasing the risk of an open bite. (Harari et al., 2010; Tang et al., 2019) Clinical features may vary depending on the area of action and the magnitude of the etiological factor. (Alhammedi et al., 2021; Festa et al., 2021; Santos Barrera et al., 2024) Morphological changes in the maxillofacial area occur because mouth breathing leads to adaptive changes in the lips, tongue, mandible position, and these changes alter the model of skeletal development through the altered neuromuscular responses. A related result is changes in the patient's soft tissue profile and face. This is due to the fact that the muscles involved in the mouth breathing contract at the same time as the muscles involved in the other oral functions and affect each other.

The upper airways can be divided into four sections: nasal cavity, nasopharynx, oropharynx and laryngopharynx. (Chen et al., 2015; Lin et al., 2022) Airway obstructions can be present in any section, but the most common is the posterior nasopharyngeal obstruction. (Chung Leng Muñoz & Beltri Orta, 2014) It is due to the pathological adenoid hypertrophy, which orthodontists associate with distal bite formation and hyperdivergent vertical growth.

Growing patients affected by pathological tonsillar hypertrophy obstructing the lower part of the upper airway medialize their lower jaw to increase the width of the oropharyngeal airway.

They develop an anterior crossbite which can progress to medial occlusion. (Grippaudo et al., 2016) Therefore, orthodontists identify two distinct facial profiles of patients who have mouth breathing, depending on the type of obstruction - progenic in tonsillar hypertrophy and prognathic in adenoid hypertrophy. (Iwasaki et al., 2017) The development of different skeletal-facial profiles as a consequence of impaired nasal breathing necessitates orthodontists to seek clarification of the etiological factor and diagnosis by an otolaryngologist. (Zhao et al., 2022; Zheng et al., 2020)

These skeletal patterns can affect the shape and size of the upper airways, but at the same time they change the bone and soft tissue facial profile and are predictors of obstructive sleep apnea (OSA) (Vu et al., 2024).

A high palatal vault is one of the most common features in patients who are mouth breathers. Tang et al. reported that the height of the palate at the first molar site was 11% higher in children who are mouth breathers than in those who breath through the nose. (Tang et al., 2019)

Studies of the described morphological changes have been done until recently on 2D images (lateral and frontal cephalograms), which provide information about the development of the facial skeleton. In the last decade, CBCT imaging has entered the orthodontic field, providing detailed, high-resolution images. They have lower radiation dose than traditional CT scans. From the captured slices, the software does a 3D reconstruction and a 3D model (volume) of the scanned area. The large volume (large field of view) CBCT scan used in the study include the calvaria. From this noninvasive examination, orthodontists obtain information about the size and position of the facial bones in the three dimensions; the relationships between them; the presence of facial asymmetries; teeth positions; temporomandibular joint conditions; the volume and position of the soft tissues. From the same examination, ENT specialists assess the volume, position and pathologies of the sinuses, nasal passages, airway volume and other parts of the head and neck. CBCT machines provide isotropy of the voxels in all three dimensions, as opposed to their anisotropy in conventional computed tomography. This results in better visualization of the head and neck bony structures in CBCT cross sections. A resolution of up to 0.09 mm is used in this study, allowing high accuracy. Otorhinolaryngologists identify the size and volume of the airways and sinuses using the CBCT examination. (Lata et al., 2018; Patil et al., 2022; Piotrowska-Seweryn et al., 2019) CBCT imaging is particularly useful in the assessment of the paranasal sinuses to evaluate their anatomy; to diagnose sinusitis, nasal polyps, and other diseases. The study is of great significance for the evaluation of airway obstructions. It helps in diagnosing conditions such as obstructive sleep apnea. It has a particular application in assessing disorders affecting the temporal bone, such as chronic otitis media or cholesteatoma, offering clear visualization of the complex structures of the ear. The information in the literature about CBCT and its use in treating ENT diseases shows that the potential of CBCT in this medical field is not yet fully known.

In summary there are multiple morphological markers indicating the impaired nasal breathing. They are often detected when developing treatment plans as part of the orthodontic analysis in order to correct the orthodontic malocclusion. In order to reduce the patient's radiation exposure during examinations by different specialists (orthodontists, ENT, pediatricians), it is important to be up-to-date with imaging methods that can provide information on hard, soft and airway structures simultaneously.

Aim: To describe a method for simultaneously identifying bone and soft tissue changes in the orofacial region.

## 2. MATERIAL AND METHODS

### *Ethics Statement*

Patients were diagnosed, treated and included in the study after the explicit informed consent of their parents. During the course of treatment, all rules and standards for good orthodontic practice applicable in the country were observed. In order to process and present the result of their treatment, approval was obtained from the Ethics Committee of KENIMUS, Approval Code: 7995/07.10.2024. The development is related to a study under the Grant project D-176/04.06.2025.

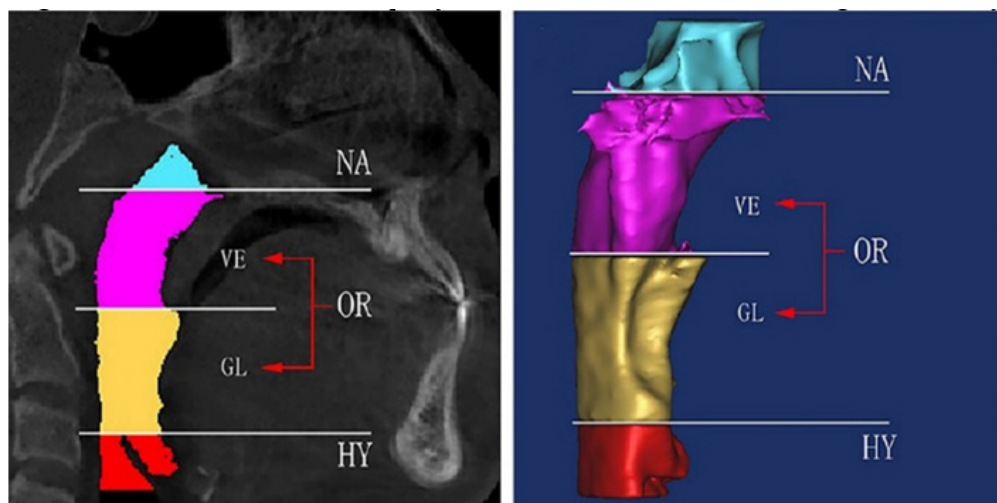
### *Diagnostic and Clinical Considerations*

The orthodontic analysis includes large field of view CBCT including the calvaria and software that is capable of segmenting hard (bones), soft tissues and airway structures. Because for patients with impaired nasal breathing, it is necessary that the scope of the study includes more structures and anatomical landmarks. The information is stored in DICOM format, which is a standard. With appropriate software, individual bone, tooth and soft tissues are segmented in order to make measurements of deviations and plan the various treatment changes. The capabilities of the software used by the team allow for measuring airway volume at different levels; assessing asymmetry in bones and soft tissues; planning and designing the treatment expander; planning orthognathic surgery; locating impacted teeth and other abnormalities.

The methodology for determining upper airway volume requires the use of reference points and planes. With CBCT, the cross-sectional area of the upper airways is evaluated and determined. (Fonseca et al., 2023) Modern software allows for measuring volume in the three segments of the trachea. Such measurements are described by Chen et al., 2015 and also from Yanev et al., 2024.

For the purpose of the study, the upper respiratory tract is divided into 3 parts: nasopharynx (NA); oropharynx (OR); hypopharynx (HY). For more complete detail, the oropharynx can be further divided into 2 parts: velopharynx (VE) and glossopharynx (GL) (Fig. 1).

Figure 1: The three divisions of the pharynx visualized on a CBCT slice and segmented airway.



Source: Authors' research

After segmenting the airway sections, the volume ( $V$ ) and height ( $h$ ) of the airway are automatically determined by the software. The average cross-sectional area is calculated as the  $V/h$  ratio. Thus, the percentage of narrowing can be determined by otorhinolaryngologists and the percentage change after orthodontic therapy (usually rapid palatal expansion) can be determined by orthodontists.

The presented case is of a 13-year-old girl with impaired nasal breathing due to oropharyngeal obstruction. Clinical examination revealed a bilateral posterior crossbite more severe in the right posterior segment, a high palatal vault, maxillary compression, minimal incisor coverage, and a short upper labial frenulum (Fig. 2). X-rays are needed to make a complete orthodontic diagnosis. Consultation with an ENT specialist is also needed, where paraclinical examinations will also be necessary. Therefore, the orthodontist prescribed a large field CBCT.

Figure 2: Intraoral status of the patient before orthodontic treatment.



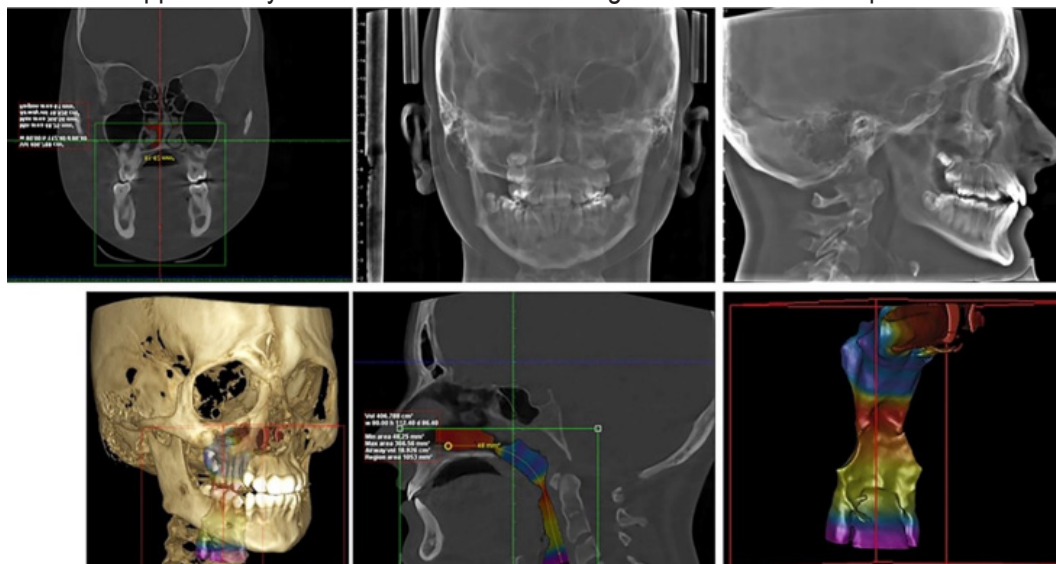
Source: Authors' research

The patient underwent orthodontic treatment after thorough diagnostics and analysis. The treatment consists of two stages - rapid palatal expansion and alignment of both dental arches and adjustment of the occlusal relationships with fixed technique - braces.

### 3. RESULTS

The three-dimensional development of the maxilla and mandible upper jaw and lower jaw; the level of upper jaw bone insufficiency in mouth breathers; the presence of facial asymmetries and the digital design of orthodontic treatment appliances were evaluated with one study. Airway volumes can be measured objectively, areas of nasopharyngeal obstructions are identified, superimposition of anatomical structures can be done, soft tissue changes are tracked, bone maturation is assessed and bone age is determined. (Fig. 3).

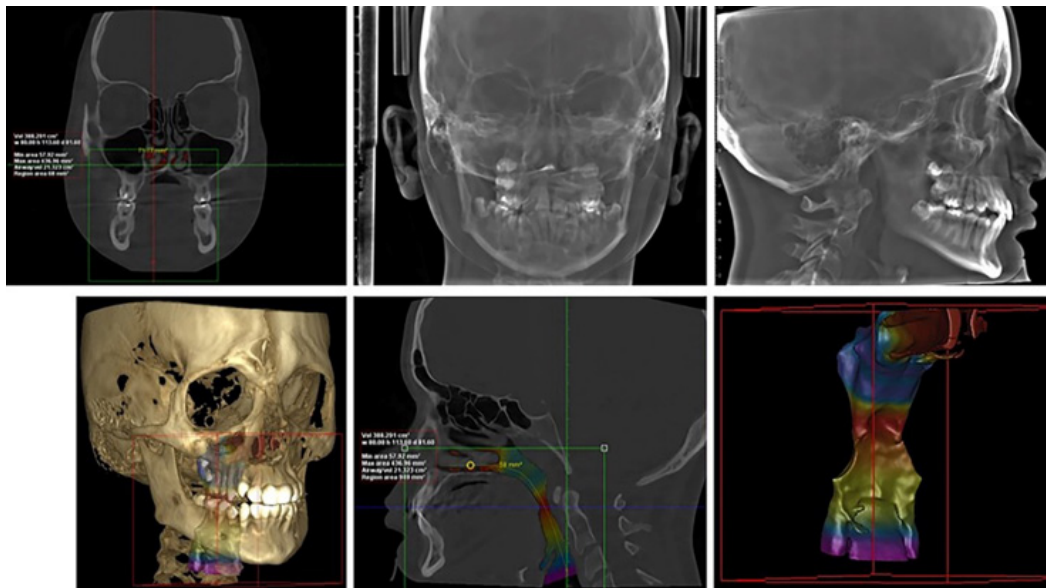
Figure 3: Figure 3: Assessment of bone and soft tissue parameters, airway volume, and sites of upper airway obstruction tracked as change from initial to finish phase



Source: Authors' research

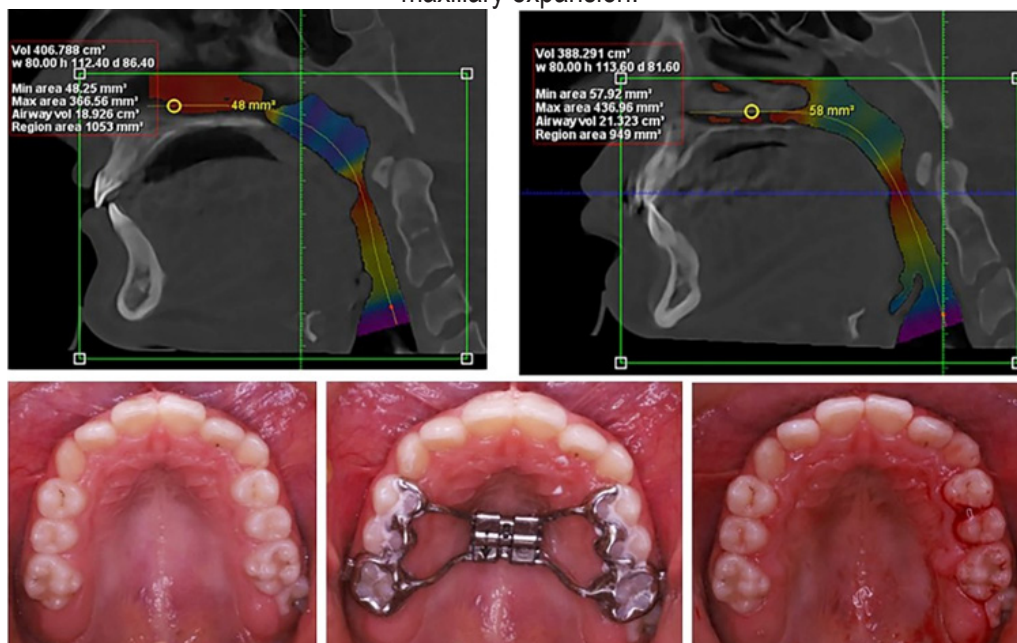
The orthodontic treatment involved maxillary expansion with a digitally designed and metal-printed expander. The increased maxillary transversal width resulted in normalization of occlusal relationships and also altered the airway volume as seen in Figures 4 and 5.

Figure 4: Assessment of bone and soft tissue parameters, airway volume and obstruction sites along the upper airways with one study after the orthodontic treatment.



Source: Authors' research

Figure 5: Comparison of maxillary transversal widths and airway volumes before and after rapid maxillary expansion.



Source: Authors' research

Orthodontic treatment starts immediately after completion of the conservative or surgical otolaryngologic therapy. Orthodontic treatment is aimed at achieving a new maxillary bone size that underlies the nasal passages and maintains their width. The transversal width of the hard palate is one of the three-dimensional parameters used to assess the volume of the upper airways. Therefore, an increase of this width will favorably increase the volume of the airways. Assessment of these parameters and their changes are possible with a single imaging study (CBCT) that allows measurements in all three planes.

#### 4. DISCUSSION

Measurements of three-dimensional structures in the orofacial region and their adjacent tissues on two dimensional images are not accurate because there is overlapping of the structures, especially when there is facial asymmetry. It is known and other authors (Aboudara et al., 2009) confirm it that lateral cephalography measures changes in the upper airway only vertically and sagittal, but the main changes after expansion are in the transverse direction. CBCT has its advantages due to its lower radiation dose and higher spatial resolution as claimed by Chen et al., 2015. Another advantage is its high resolution, which allows for the use of many more landmarks and visible bone structures. By using the stable structures at the base of the skull as markers, it is possible to register pre- and post-treatment 3D patterns. CBCT provides a new standard for volumetric measurements, airway cross-sectional area analysis and making more accurate diagnosis.

In the presented clinical case, the airway volume increased from 18.926 cm<sup>3</sup> to 21.323 cm<sup>3</sup>. It was found that the expansion of the maxilla is directly proportional to the increase in volume in the nasopharynx and oropharynx. Spontaneous medial displacement of the mandible, hyoid bone is observed, which also affects the surrounding soft tissues. When treating patients with maxillary expander, the orthopedic forces that are used, stimulate cellular activity in the palatal suture where growth occurs. After treatment with a rapid maxillary expander, the expanded maxilla provides more space for the tongue. Due to this fact, the mandible shifts and adapts in relation to the upper jaw. The mandible shift is observed as backwards (clockwise) rotation. These observations confirm the relationship between the skeletal structures of the craniofacial complex and the upper airways.

#### 5. CONCLUSION

CBCT is a reliable method and has a number of advantages over other methods for volumetric airway analysis. At the same time, CBCT provides data relevant for orthodontic evaluation of the skeletal components of malocclusions that occur in mouth breathing patients. Therefore, it is recommended that a single protocol to be established when diagnostic tests are prescribed by different specialists, who are involved in the management of patients with mouth breathing. This protocol recommends this diagnostic test to be large field CBCT.

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# IMPACT OF INOSITOL SUPPLEMENTATION ON ENDOCRINE FUNCTION, MENTAL HEALTH AND CARDIOVASCULAR RISK FACTORS: A CLINICAL STUDY

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**Abstract:** This study investigates the effects of 30 mg inositol supplementation on endocrine, mental health, and cardiovascular parameters in 20 participants. Pre- and post-treatment measurements were taken to evaluate changes in insulin, androgen levels, glucose, blood pressure, lipid profiles (LDL, HDL, total cholesterol, triglycerides), depression, anxiety, general mental clarity, energy, and fatigue. Results showed significant improvements in endocrine and cardiovascular parameters, including a reduction in insulin levels (from 15  $\mu$ U/mL to 11  $\mu$ U/mL,  $p=0.05$ ), androgen levels (from 50 ng/dL to 45 ng/dL,  $p=0.04$ ), and blood pressure (from 140/100 mmHg to 115/75 mmHg,  $p=0.05$ ). Lipid profiles also improved, with LDL decreasing from 135 mg/dL to 120 mg/dL ( $p=0.02$ ), HDL increasing from 45 mg/dL to 55 mg/dL ( $p=0.03$ ), and triglycerides decreasing from 150 mg/dL to 130 mg/dL ( $p=0.04$ ). Mental health assessments revealed significant reductions in depression (PHQ-9 score from 10 to 5,  $p=0.02$ ) and anxiety (GAD-7 score from 8 to 4,  $p=0.01$ ), along with an improvement in general mental clarity (from 60 to 75,  $p=0.04$ ). Energy levels showed a significant increase (from 60 to 75,  $p=0.05$ ), while fatigue was slightly reduced, but not significantly (from 70 to 60,  $p=0.07$ ). These findings suggest that inositol supplementation may offer substantial benefits in improving metabolic, cardiovascular, and mental health outcomes. Further studies with larger sample sizes and longer durations are needed to confirm these results and explore the underlying mechanisms of action.

**Keywords:** *Inositol, endocrine parameters, cardiovascular parameters, depression, mental health*

**Field:** Pharmacoeconomics, Pharmacy

## 1. INTRODUCTION

Inositol is a natural compound that plays a key role in maintaining health and balance within the body. Although often mentioned in the context of the B-complex vitamins, inositol is also considered an effective probiotic due to its ability to support gut health, improve the digestive system, and contribute to the balance of the microbiome (Chatree et al., 2020). Furthermore, inositol has numerous positive effects on the heart, endocrine system, and overall health. Inositol's digestive effects include helping to maintain the balance of gut microflora, thereby supporting the digestive system. It has a positive impact on digestion regulation, reducing bloating, and alleviating issues such as irritable bowel syndrome (IBS). In addition, inositol has a significant effect on heart health, as it helps regulate blood lipid levels. It aids in lowering bad cholesterol (LDL) and increasing good cholesterol (HDL), which may reduce the risk of atherosclerosis and heart disease. It also plays a role in blood pressure regulation. While the effect of inositol on blood pressure is still under investigation, there is evidence suggesting it may help lower blood pressure, particularly in individuals with hypertension. Inositol also supports the health of blood vessels and may improve vascular function, contributing to overall cardiovascular health. Inositol is especially beneficial for women with hormonal imbalances, such as those with polycystic ovary syndrome (PCOS). It regulates insulin levels and helps improve insulin sensitivity, which is crucial for individuals with insulin resistance, commonly seen in PCOS. Improved insulin sensitivity can lower blood insulin levels and reduce the risk of developing type 2 diabetes. Inositol also helps reduce levels of male hormones (androgens) in women with PCOS, which can assist in alleviating symptoms like acne and excessive hair growth (hirsutism). The use of inositol can improve ovulation in women with PCOS and increase the chances of pregnancy. Inositol has a positive effect on mental health by reducing symptoms of stress, anxiety, and depression. It also helps maintain balance in the nervous system, which can improve overall well-being, increase energy, and reduce fatigue (Zarezadeh et al., 2022). Acting as an antioxidant, inositol helps protect cells from damage caused by free radicals. Inositol is a versatile compound that offers numerous health benefits, including support for the digestive, cardiovascular, and endocrine systems, as well as mental health. Due to its wide range of benefits, inositol is becoming increasingly popular as a dietary supplement, particularly for individuals with hormonal imbalances, metabolic syndrome, or heart

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health concerns.

## 2. MATERIAL AND METHODS

The study will focus on the effects of inositol (30 mg daily) as a probiotic on overall health, the endocrine system, and cardiovascular health in 20 participants who will use the supplement for one month. During the study, participants will take 30 mg of inositol daily, and the effects will be monitored through various parameters. Initial measurements will include blood pressure, lipid profile (LDL, HDL, total cholesterol, triglycerides), glucose and insulin levels, and hormonal status (especially androgen levels in women with PCOS). Additionally, participants will complete mental health questionnaires (e.g., GAD-7 for anxiety, PHQ-9 for depression), as well as general health questionnaires (e.g., SF-36) to assess the effects on energy, fatigue, and mental clarity. After one month, the same tests and questionnaires will be repeated to evaluate changes in health. Statistical analysis will include comparisons of pre- and post-supplementation results using a t-test to analyze changes in parameters. The study was conducted in accordance with ethical guidelines, with prior consent from all participants, and was anonymous in nature, ensuring the confidentiality of all collected data. It is expected that inositol will have a positive impact on microbiome balance, improved insulin sensitivity, lipid regulation, reduction of stress, anxiety, and depression, as well as overall health improvement, including reduced fatigue and increased energy.

## 3. RESULTS

The results of endocrine parameters in 20 participants before and after the use of 30 mg of inositol are presented in Table 1. The endocrine parameters analyzed in Table 1. include insulin, androgen levels, and glucose. Before inositol treatment, the insulin level was 15  $\mu$ U/mL, which decreased to 11  $\mu$ U/mL after treatment, with a statistical significance of 0.05. Similarly, androgen levels dropped from 50 ng/dL to 45 ng/dL after treatment, with a statistical significance of 0.04. Finally, glucose levels decreased from 95 mg/dL to 80 mg/dL following treatment, with a statistical significance of 0.04.

Table 1. Endocrine parameters before and after inositol 30mg treatment

<b>Endocrine parameter</b>	<b>Before treatment with <i>Inositol 30mg</i> (Mean <math>\pm</math> SD)</b>	<b>After treatment with <i>Inositol 30mg</i> (Mean <math>\pm</math> SD)</b>	<b>p-value (<math>p=0.05</math>)</b>
<i>Insulin (<math>\mu</math>U/mL)</i>	15 $\pm$ 5	12 $\pm$ 4	0.05
<i>Androgen levels (ng/dL)</i>	50 $\pm$ 10	45 $\pm$ 8	0.04
<i>Glucose (mg/dL)</i>	95 $\pm$ 10	80 $\pm$ 8	0.04

**SD-** standard deviation

Source: Authors' research

The parameters of depression and mental health before and after the use of 30 mg of inositol in 20 participants are presented in Table 2. These parameters included standardized questionnaires for assessing depression and anxiety (GAD-7 and PHQ-9), general mental clarity, and energy and fatigue assessment questionnaires (SF-36 Energy and SF-36 Fatigue). GAD-7 and PHQ-9 scores prior to inositol treatment were 8 and 10, respectively. After treatment, the scores decreased to 4 and 5, demonstrating significant statistical relevance with  $p=0.01$  and  $p=0.02$ . General mental ability also showed a significant improvement from 60 to 75 after treatment ( $p=0.04$ ). Additionally, SF-36 Energy increased from 60 to 75 following treatment, with statistical significance confirmed at  $p=0.05$ . However, while SF-36 Fatigue decreased from 70 to 60 after treatment, the reduction did not reach statistical significance ( $p=0.07$ ).

Table 2. Depression and mental health parameters before and after inositol 30mg treatment

<b>Depression and Mental health parameters</b>	<b>Before treatment with Inositol 30mg (Mean ± SD)</b>	<b>After treatment with Inositol 30mg (Mean ± SD)</b>	<b>p-value (p=0.05)</b>
<i>GAD-7 (Anxiety)</i>	8±3	4±2	0.01
<i>PHQ-9 (Depression)</i>	10±4	5±3	0.02
<i>General mental ability</i>	60±12	75±14	0.04
<i>SF-36 (Energy)</i>	60±10	75±12	0.05
<i>SF-36 (Fatigue)</i>	70±12	60±11	0.07

**SD**-standard deviation; **GAD-7, PHQ-9**- Standardized questionnaire for depression and anxiety; **SF-36**- Questionnaires for assessing energy and fatigue

Source: Authors' research

Table 3. presents the results of cardiovascular parameters in 20 participants before and after the use of 30 mg of inositol. The cardiovascular parameters included: blood pressure, LDL, HDL, total cholesterol, and triglycerides. Before inositol administration, blood pressure was 140/100 mmHg, and after treatment, it decreased to 115/75 mmHg, which was statistically significant (p=0.05). LDL and HDL cholesterol levels were 135 mg/dL and 45 mg/dL, respectively, before treatment. After inositol administration, LDL decreased to 120 mg/dL, while HDL increased to 55 mg/dL, with statistical significance confirmed at p=0.02 and p=0.03. Total cholesterol and triglycerides were 200 mg/dL and 150 mg/dL, respectively, before treatment. After treatment, total cholesterol decreased to 180 mg/dL, and triglycerides to 130 mg/dL, with statistical significance confirmed at p=0.01 and p=0.04.

Table 3. Cardiovascular parameters before and after inositol 30mg treatment

<b>Cardiovascular parameters</b>	<b>Before treatment with Inositol 30mg (Mean ± SD)</b>	<b>After treatment with Inositol 30mg (Mean ± SD)</b>	<b>p-value (p=0.05)</b>
<i>Blood pressure (mmHg)</i>	140/100±10	115/75±9	0.05
<i>LDL (mg/dL)</i>	135±25	120±23	0.02
<i>HDL (mg/dL)</i>	45±10	55±12	0.03
<i>Total cholesterol (mg/dL)</i>	200±30	180±28	0.01
<i>Triglycerides (mg/dL)</i>	150±35	130±32	0.04

**SD**-standard deviation

Source: Authors' research

#### 4. CONCLUSION

The results of this study suggest that the administration of 30 mg of inositol in 20 participants led to significant improvements in several key health parameters. Endocrine markers, including insulin, androgen levels, and glucose, showed notable positive changes, indicating potential benefits for metabolic health. Mental health indicators, such as depression, anxiety, and general mental clarity, also improved, with significant reductions in GAD-7 and PHQ-9 scores and increased mental ability. Cardiovascular health was positively affected, with reductions in blood pressure, LDL cholesterol, and triglyceride levels, alongside an increase in HDL cholesterol. These findings suggest that inositol supplementation may offer therapeutic benefits for both metabolic and cardiovascular health, as well as mental well-being. Further research is needed to confirm these results and assess the long-term effects.

#### 5. DISCUSSION

The results of this study provide valuable insights into the potential therapeutic effects of 30 mg inositol supplementation on various health parameters. The significant improvements observed in endocrine, mental health, and cardiovascular markers highlight the multifaceted benefits of inositol, which align with previous research supporting its role in metabolic regulation, mood enhancement, and cardiovascular health. In terms of endocrine parameters, the observed reductions in insulin and androgen levels and the slight decrease in glucose levels suggest that inositol may play a role in improving metabolic health, particularly in insulin sensitivity and the management of androgen-related conditions. Previous

studies have demonstrated inositol's efficacy in managing insulin resistance, particularly in conditions such as polycystic ovary syndrome (PCOS), which is associated with both insulin resistance and elevated androgen levels (Kamenov i Gateva, 2020; Roseff i Montenegro, 2020; Facchinetti et al., 2019). The significant reduction in insulin levels (from 15  $\mu$ U/mL to 11  $\mu$ U/mL) and the decrease in androgen levels are consistent with these findings, supporting the hypothesis that inositol may help modulate endocrine function (Greff et al., 2023). Mental health parameters also showed promising results, with significant reductions in both depression and anxiety, as measured by the GAD-7 and PHQ-9 scores, alongside an improvement in general mental clarity. The increase in mental ability scores further suggests a potential cognitive-enhancing effect of inositol. These findings corroborate existing literature that highlights inositol's role in modulating serotonin pathways, which may contribute to its antidepressant and anxiolytic effects (Blampied, 2021). The increase in energy levels observed, although statistically significant, was tempered by the lack of significant improvement in fatigue levels ( $p=0.07$ ). This discrepancy warrants further investigation to determine whether longer treatment durations or higher doses may be necessary to achieve more consistent improvements in fatigue (Mashayekh-Amiri et al., 2022). Regarding cardiovascular health, the observed reductions in blood pressure, LDL cholesterol, and triglyceride levels, as well as the increase in HDL cholesterol, are of particular interest. Inositol has previously been suggested to have lipid-lowering effects, which is supported by our findings showing a significant reduction in both LDL (from 135 mg/dL to 120 mg/dL) and triglycerides (from 150 mg/dL to 130 mg/dL), coupled with an increase in HDL (from 45 mg/dL to 55 mg/dL) (Shokrpour, et al., 2019). These changes are consistent with the growing body of research that suggests inositol may have a favorable impact on lipid metabolism, potentially reducing the risk of cardiovascular diseases (Shokrpour, et al., 2019). Additionally, the significant decrease in blood pressure (from 140/100 mmHg to 115/75 mmHg) supports the notion that inositol may help improve vascular health, potentially through mechanisms such as enhanced endothelial function and reduced arterial stiffness (Tari et al., 2021). However, several limitations must be considered. The sample size of 20 participants is relatively small, and the duration of treatment was not specified, which may affect the generalizability of the findings. Additionally, the lack of statistically significant improvement in fatigue ( $p=0.07$ ) calls for further investigation into the optimal dose and treatment duration required to achieve more consistent results in this domain. Further studies with larger sample sizes and more rigorous control conditions are necessary to confirm the long-term effects of inositol supplementation and to determine its potential role as a therapeutic agent in managing metabolic, cardiovascular, and mental health disorders. In conclusion, this study provides promising evidence for the efficacy of 30 mg inositol supplementation in improving endocrine function, mental health, and cardiovascular health. These findings contribute to the growing body of literature supporting the multifactorial benefits of inositol, although further research is needed to better understand the underlying mechanisms and long-term clinical implications.

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# ASSESSMENT OF SENSORY PROCESSING IN CHILDREN WITH AUTISM SPECTRUM DISORDER USING THE SHORT SENSORY PROFILE: A STUDY OF 60 PARTICIPANTS

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**Abstract:** Alterations in sensory processing are widely recognized as a fundamental characteristic of Autism Spectrum Disorder and play a critical role in shaping everyday functioning, behavioral responses, and participation in daily activities. The precise evaluation of these sensory characteristics is crucial for designing effective intervention strategies, particularly when applying integrated rehabilitation models. The present study was designed to investigate patterns of sensory processing in children diagnosed with ASD through the use of the Short Sensory Profile, with emphasis on its role in informing a combined physiotherapy and occupational therapy framework. The sample consisted of 60 children within the age range of 4 to 7 years. Sensory processing characteristics were measured using the Short Sensory Profile, a standardized caregiver-based assessment tool that examines multiple domains, including tactile responsiveness, movement-related sensitivity, and low energy/weakness. Data were collected as part of an initial comprehensive assessment within an integrated therapeutic framework combining physiotherapy and occupational therapy interventions. Descriptive and inferential statistical analyses were conducted to examine the distribution and severity of sensory processing differences. The results indicated that the majority of participants exhibited definite differences across multiple sensory domains. Specifically, approximately 69% of the children demonstrated definite differences in at least two sensory domains. The most pronounced impairments were identified in tactile sensitivity, movement sensitivity, and the low energy/weakness subscale. Children within this profile demonstrated reduced muscle strength, poor postural control, and limited endurance. They fatigued easily, particularly during activities requiring sustained posture or physical effort, exhibited weak grip strength, experienced difficulty lifting age-appropriate objects, and frequently required external support even during routine tasks. These findings highlight the strong relationship between sensory processing difficulties and motor function in children with ASD. The identified patterns emphasize the importance of integrating sensory-based approaches with targeted motor and functional training. The Short Sensory Profile proved to be a valuable tool for guiding individualized intervention planning within a comprehensive therapeutic model. In conclusion, this study provides evidence that specific sensory processing deficits—particularly in tactile, movement, and low energy domains—should be central considerations in intervention design. The integration of sensory-based strategies within combined physiotherapy and occupational therapy programs may improve functional outcomes and enhance participation in daily activities for children with ASD. Future research should explore the long-term effects of such integrated interventions on sensory and motor development.

**Keywords:** *sensory processing, autism spectrum disorder, short sensory profile, sensory integration, physiotherapy, occupational therapy.*

**Field:** Medical Sciences and Health

## 1. INTRODUCTION

Over the past decades, Autism Spectrum Disorder has increasingly been recognized as a major challenge for healthcare systems, education, and society as a whole, largely due to its rising prevalence and its multifaceted impact on child development and family well-being (World Health Organization, 2023; Zeidan et al., 2022). Rather than affecting a single developmental domain, ASD is characterized by a wide spectrum of neurodevelopmental features that extend beyond social interaction and behavior to include sensory functioning, motor performance, and the ability to engage in everyday activities (Lord et al., 2020; Schaaf & Lane, 2015). In recent years, scientific interest has shifted toward understanding sensory processing differences as a fundamental factor influencing adaptive functioning in this population. Accumulating evidence suggests that atypical sensory responses are highly common and play a significant role in shaping motor abilities, behavioral regulation, and overall participation in daily life (Ben-Sasson et al., 2009; Tomchek & Dunn, 2007; Tavassoli et al., 2014). Sensory processing can be understood as the neurological mechanism through which the brain interprets and organizes incoming sensory input to generate appropriate behavioral responses. This process relies on the coordinated activity of multiple sensory systems, particularly tactile, vestibular, and proprioceptive pathways, which are essential for

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effective interaction with the environment and motor execution (Ayres, 2005). When these mechanisms are disrupted, children may experience difficulties in modulating sensory input, leading to either heightened or diminished sensitivity, as well as challenges in self-regulation and functional participation (Schaaf & Lane, 2015). Such sensory-related difficulties are frequently accompanied by motor impairments, including deficits in balance, coordination, and motor planning (Fournier et al., 2010; Green et al., 2009). These limitations can significantly restrict independence and reduce engagement in age-appropriate activities (Bhat et al., 2011). Moreover, inefficient sensory processing has been linked to compromised postural stability and suboptimal movement strategies, further influencing motor development. Current research highlights that postural control depends on the effective integration of multisensory input, particularly from vestibular and proprioceptive systems (Shumway-Cook & Woollacott, 2017). In children with ASD, disruptions in this integration often result in instability, increased body sway, and reduced movement efficiency. Evidence from intervention studies indicates that combining sensory integration techniques with physiotherapy-based exercises can lead to meaningful improvements in balance, coordination, and postural control (Mihaylov, 2026). Given the widespread presence and functional consequences of sensory processing differences, the use of reliable and standardized assessment tools is critical for identifying individual sensory profiles and informing intervention planning. The Short Sensory Profile is among the most commonly applied instruments for evaluating sensory processing across several domains, including tactile and movement sensitivity as well as low energy/weakness (Dunn, 1999; McIntosh et al., 1999). Previous research has demonstrated its acceptable reliability and validity in identifying sensory-related difficulties in this population (Tomchek & Dunn, 2007). Nevertheless, despite its extensive application in both research and clinical settings, further investigation is needed to clarify how specific sensory processing patterns relate to motor impairments and how these findings can be effectively translated into targeted intervention strategies. In particular, there is a lack of studies examining how sensory assessment outcomes can directly inform the development of integrated therapeutic models that combine physiotherapy and occupational therapy. Accordingly, the present study aims to examine sensory processing characteristics in children with ASD using the Short Sensory Profile and to explore their implications for individualized intervention planning within a comprehensive therapeutic framework integrating physiotherapy and occupational therapy.

## 2. MATERIALS AND METHODS

A total of 60 children with a confirmed diagnosis of Autism Spectrum Disorder, in early childhood (4–7 years), participated in the present study. The diagnosis for all participants had been previously established in accordance with the criteria outlined in the DSM-5, based on comprehensive clinical records and specialist evaluation. The sample was subsequently divided into two equal groups, comprising an experimental group ( $n = 30$ ) and a control group ( $n = 30$ ). The evaluation of sensory processing was performed at the beginning of the therapeutic process, before the introduction of any structured intervention program. This initial assessment aimed to identify baseline sensory characteristics and to provide a foundation for individualized therapeutic planning. The study followed an observational and descriptive-analytical design, focusing on the identification and analysis of sensory processing patterns and their practical relevance for developing an integrated intervention model combining physiotherapy and occupational therapy. Sensory functioning was examined using the Short Sensory Profile, a standardized caregiver-reported instrument designed to evaluate multiple dimensions of sensory behavior. The tool encompasses several subdomains, including tactile sensitivity, movement sensitivity, auditory responsiveness, visual/auditory sensitivity, oral sensitivity, under-responsiveness/sensory seeking, and low energy/weakness. For the purposes of the current investigation, particular attention was directed toward three key areas—tactile processing, movement-related sensitivity, and low energy/weakness—given their close association with motor performance, postural regulation, and physical endurance in this population. Each subscale consists of items describing observable behaviors, rated according to their frequency. The scores obtained were aggregated and interpreted using standardized cut-off values, enabling categorization into “typical performance,” “probable difference,” and “definite difference.” Data were systematically organized for each subscale, with individual composite scores calculated for every participant. Emphasis was placed on analyzing the distribution of scores within the primary domains of interest, allowing for comparative evaluation across participants and identification of prevailing sensory processing profiles within the sample. The findings were summarized in tabular format, presenting both individual and aggregated data for each domain, thereby facilitating analysis at both the individual and group levels. Statistical processing involved descriptive indicators such as mean values, standard deviations, and frequency distributions, alongside inferential statistical methods used to examine the prevalence and severity of sensory

processing differences. Overall, the data derived from the Short Sensory Profile served as a basis for exploring the relationship between sensory processing characteristics and motor functioning, as well as for substantiating the application of an integrated therapeutic framework that combines physiotherapy and occupational therapy approaches.

### 3. RESULTS

Analysis of the data derived from the Short Sensory Profile highlighted considerable variability in sensory processing among children with Autism Spectrum Disorder. As illustrated in Table 1, participants were distributed unevenly across the evaluated sensory domains. A substantial proportion of the sample was classified within the definite difference range, most notably in tactile processing, movement-related sensitivity, under-responsiveness/sensory seeking behaviors, and low energy/weakness.

Table 1. Distribution of sensory processing profiles based on Short Sensory Profile (n = 60)

Section	Max Score	Typical Performance n (%)	Probable Difference n (%)	Definite Difference n (%)
<b>A. Tactile Sensitivity</b>	/35	14 (23.3%)	18 (30.0%)	<b>28 (46.7%)</b>
<b>B. Oral Sensitivity</b>	/20	20 (33.3%)	16 (26.7%)	24 (40.0%)
<b>C. Movement Sensitivity</b>	/15	12 (20.0%)	17 (28.3%)	<b>31 (51.7%)</b>
<b>D. Under-responsiveness / Sensory Seeking</b>	/35	15 (25.0%)	19 (31.7%)	<b>26 (43.3%)</b>
<b>E. Auditory Sensitivity</b>	/30	18 (30.0%)	20 (33.3%)	22 (36.7%)
<b>F. Low Energy / Weakness</b>	/30	10 (16.7%)	16 (26.7%)	<b>34 (56.6%)</b>
<b>G. Visual/Auditory Sensitivity</b>	/25	17 (28.3%)	18 (30.0%)	25 (41.7%)
<b>Total Score</b>	/190	11 (18.3%)	20 (33.3%)	<b>29 (48.4%)</b>

Source: Authors own research, 2026.

A chi-square ( $\chi^2$ ) analysis was conducted to evaluate the distribution of sensory processing differences across the assessed domains. The analysis revealed a statistically significant variation between domains ( $\chi^2(12) = 26.84, p < 0.01$ ). The greatest proportion of participants classified with definite differences was identified in the following areas:

- Low energy/weakness (56.6%)
- Movement sensitivity (51.7%)
- Tactile sensitivity (46.7%)

Furthermore, approximately 69% of the children exhibited definite differences in at least two of the primary domains (tactile, movement, and low energy), reinforcing the pattern outlined in the abstract. A comparative baseline analysis between the experimental and control groups, performed using an independent samples t-test, did not reveal statistically significant differences ( $p > 0.05$ ), indicating that both groups were comparable prior to the initiation of the intervention (Author own research, 2026). Children categorized within the low energy/weakness profile displayed decreased muscle strength, insufficient postural stability, and reduced endurance capacity. These children demonstrated rapid fatigue, particularly during activities requiring sustained postural engagement or physical effort, and often relied on additional external support. Similarly, deficits in movement and tactile sensitivity were associated with challenges in motor planning, coordination, and the ability to generate appropriate adaptive responses to sensory incentives (Author own research, 2026).

### 4. DISCUSSION

The findings of the present study add to the growing body of evidence identifying sensory processing impairments as a key feature in the clinical presentation of children with ASD. The observed pattern of results highlights a pronounced prevalence of difficulties in tactile processing, movement-related sensitivity, sensory under-responsiveness, and low energy/weakness, aligning with trends documented in recent literature. Comparable outcomes have been reported by Salah et al. (2024), who applied the Short Sensory Profile to examine children with ASD and ADHD, identifying widespread sensory processing challenges, particularly in tactile and movement-related domains. This convergence of findings supports the reliability of the present results and reinforces the consistency of these sensory characteristics within the ASD population. A notable outcome of this study is the prominence of the low energy/weakness profile, which was strongly associated with diminished muscular strength, compromised postural control, and decreased endurance. These findings are consistent with recent research exploring the functional

implications of sensory processing differences. For example, Kinter et al. (2024) demonstrated significant associations between sensory processing patterns and both eating behaviors and quality of life, underscoring the broader impact of these difficulties on daily functioning. In parallel, contemporary large-scale studies investigating sensory subgroups in ASD emphasize the considerable variability in sensory profiles. Different configurations of sensory processing differences appear to lead to distinct functional outcomes. This variability is critical when interpreting the present findings, as it suggests that, despite the identification of dominant patterns, individualized differences must remain central to therapeutic decision-making. Additional evidence (Research in Autism Spectrum Disorders, 2024) indicates a direct relationship between the severity of autistic traits and the extent of sensory processing differences, further supporting the link identified in this study between sensory and motor functioning. The application of the SSP in this study confirms its usefulness as a screening and evaluative tool, in agreement with recent literature (Din et al., 2023). However, previous psychometric analyses (Williams et al., 2018) have highlighted certain limitations, noting that while overall reliability is acceptable, variability within subscales and limitations of total score interpretation should be considered. This critical perspective is particularly relevant in the context of the current findings. Although SSP provides valuable insights into sensory processing characteristics, it does not fully capture the complexity of functional impairments when used in isolation. Consequently, there is a clear need for a more comprehensive approach that integrates sensory assessment with motor evaluation and targeted intervention strategies. The present findings support the implementation of a combined therapeutic model incorporating physiotherapy and occupational therapy. The identified deficits in tactile and movement processing, along with reduced endurance, necessitate interventions addressing both sensory modulation and motor performance, including postural control, strength, and functional movement skills. Modern frameworks such as the ISF emphasize the importance of linking impairments to real-world functioning and participation (Marcilla-Jordá et al., 2024/2025), further reinforcing the need for multidisciplinary and holistic intervention approaches. Several limitations should be acknowledged. The reliance on caregiver-reported data introduces potential subjectivity, and the absence of longitudinal follow-up restricts the ability to assess changes over time. Despite these limitations, the study provides a meaningful basis for future intervention-focused research.

## 5. CONCLUSION

The results of this study indicate that impairments in tactile processing, movement sensitivity, sensory under-responsiveness, and low energy/weakness represent some of the most prominent features among the pediatric population diagnosed with ASD. While the Short Sensory Profile proves to be a valuable initial assessment instrument, the findings highlight the importance of complementing it with integrated therapeutic strategies. In this context, the combination of physiotherapy and occupational therapy emerges as a well-founded and effective approach for enhancing functional abilities and participation in everyday activities.

## ETHICAL CONSIDERATIONS

All procedures within the study were conducted in full compliance with recognized ethical principles governing research with human subjects. Participation was voluntary, and written informed consent was secured from the parents or legal representatives of all children prior to their inclusion. Particular care was taken to safeguard the privacy of participants, maintain data confidentiality, and uphold the rights and welfare of the children throughout the research process.

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# THE IMPACT OF ULTRA-PROCESSED FOODS ON THE GLOBAL OBESITY EPIDEMIC

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**Abstract:** Obesity has become one of the most urgent health concerns worldwide, shaped by a complicated mix of biological, lifestyle, and environmental influences. Among these, the fast rise in intake of ultra-processed foods (UPFs) has attracted increasing scientific scrutiny. UPFs, defined within the NOVA classification system as industrial formulations composed of refined ingredients and additives, are marked by substantial caloric concentration, excessive sugar, salt, and unhealthy fats, and low nutritional quality. This narrative review synthesizes current epidemiological evidence linking UPF consumption with obesity-related outcomes, including increased body mass index, abdominal adiposity, and metabolic dysfunction. Proposed mechanisms include impaired satiety signaling, alterations in gut microbiota, activation of neurobiological reward pathways, and promotion of chronic low-grade inflammation. While observational studies consistently demonstrate positive associations, methodological challenges and controversies—such as confounding lifestyle factors and limitations in dietary assessment—remain unresolved. Nevertheless, the convergence of biological plausibility and epidemiological findings underscores the immediate need for comprehensive public health strategies aimed at reducing UPF intake. Policy interventions including taxation, labeling, marketing restrictions, and product reformulation may represent critical tools in mitigating the global obesity epidemic.

**Keywords:** *obesity, ultra-processed foods, NOVA classification, public health, food industry*

**Field:** Medical Sciences

## 1. INTRODUCTION

Obesity has become one of the most serious global public health concerns of the contemporary era, with continuously increasing prevalence affecting individuals regardless of age or socioeconomic status. Characterized by exaggerated concentration of adipose tissue that may impair health, obesity is strongly connected with a wide range of chronic conditions, including type 2 diabetes mellitus, cardiovascular disease, hypertension, dyslipidemia, certain malignancies, and musculoskeletal disorders. Beyond its clinical consequences, obesity imposes substantial economic and social burdens on healthcare systems worldwide through elevated healthcare costs, diminished productivity, and erosion of life standards.

Over recent decades, profound transformations in global food systems and dietary behaviors have occurred because of urbanization, industrialization, economic development, and globalization. Conventional eating habits based predominantly on fresh and minimally processed foods have increasingly been replaced by highly industrialized food products that are convenient, inexpensive, aggressively marketed, and widely accessible. These changes have coincided temporally with the rapid escalation of obesity rates observed worldwide, suggesting that modern dietary environments may play a critical role in obesity development.

Within this context, increasing scientific attention has focused on ultra-processed foods (UPFs), a category established through the NOVA food classification system. UPFs are industrial formulations manufactured primarily from refined substances derived from foods, chemically altered ingredients, and cosmetic additives intended to improve palatability, appearance, shelf life, and convenience. Common examples include sugar-sweetened beverages, packaged snacks, fast foods, processed meats, instant meals, and sweetened breakfast cereals. These products are typically defined by high-power density, excessive amounts of sugar, salt, and unhealthy fats, as well as low fiber and micronutrient content.

Growing proof indicates that excessive UPF consumption may contribute significantly to obesity and metabolic dysfunction through numerous biological and behavioral mechanisms. Proposed pathways include increased caloric intake due to hyper-palatability, impaired satiety signaling, alterations in gut microbiota, inflammatory responses, hormonal dysregulation, and activation of neurobiological reward systems. Furthermore, epidemiological studies conducted across diverse populations have consistently demonstrated associations between high UPF consumption and increased body mass index (BMI), abdominal obesity, and long-term weight gain.

Regardless of the cumulative research supporting this relationship, important controversies and methodological challenges remain unresolved. Questions persist regarding the independent role of food

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processing relative to nutrient composition, limitations of dietary assessment methods, and potential confounding lifestyle factors influencing observed associations. Consequently, comprehensive evaluation of current evidence is necessary to enhance comprehension of the contribution of UPFs to the global obesity epidemic.

This review aims to critically investigate the connection between ultra-processed food intake and obesity by summarizing current epidemiological evidence, exploring underlying biological mechanisms, and discussing broader public health implications and future research directions.

## 2. MATERIALS AND METHODS

A narrative literature review was conducted to evaluate current scientific evidence regarding the correlation between ultra-processed food dietary intake and obesity. Relevant articles were identified through electronic database searches performed using PubMed, Scopus, Web of Science, and Google Scholar.

The search methodology included fusion of the following keywords and Medical Subject Headings (MeSH) terms: “ultra-processed foods,” “obesity,” “NOVA classification,” “body mass index,” “metabolic syndrome,” “dietary patterns,” “food processing,” and “weight gain.” Priority was given to studies published between 2010 and 2025 in peer-reviewed scientific journals.

Eligible sources included systematic reviews, randomized controlled trials meta-analyses, cross-sectional studies, cohort studies, and major policy or consensus reports addressing the relationship between UPFs and obesity-related outcomes. Additional related references were determined through manual inspection of bibliographies from selected publications.

Studies focusing primarily on unrelated dietary exposures or lacking clear relevance to obesity outcomes were excluded. Preference was given to high-quality studies involving large population samples and standardized dietary assessment methodologies. The collected literature was analyzed and synthesized thematically, with particular emphasis placed on definitions and classification of ultra-processed foods, epidemiological evidence, biological mechanisms linking UPFs and obesity, and public health implications.

## 3. RESULTS

### 3.1. Ultra-Processed Foods: Definition and Classification

The categorization of foods based on the degree and purpose of industrial processing has emerged as an important framework in nutritional epidemiology. Among the most widely used systems is the NOVA classification, which classifies foods into four groups according to the degree of processing involved in their production. These categories include unprocessed or minimally processed foods, processed culinary ingredients, processed foods, and ultra-processed foods.

Ultra-processed foods represent the most industrially modified category within the NOVA system. They are typically manufactured using food-extracted or food-derived compounds, including refined starches, sugars, oils, protein isolates, and hydrogenated fats, combined with additives such as emulsifying agents, colorants, flavor boosters, sweeteners, and preservatives. In contrast to minimally processed foods, UPFs generally contain few intact whole-food components and are designed primarily for convenience, extended shelf life, and enhanced sensory appeal.

Examples of UPFs include carbonated soft drinks, packaged confectionery products, sweetened breakfast cereals, instant soups, fast foods, processed meat products, industrial bakery items, and ready-to-eat frozen meals. These products frequently possess high energy density while containing excessive levels of added sugars, sodium, and saturated or trans fats. Simultaneously, they are often deficient in dietary fiber, vitamins, minerals, and other health-promoting bioactive compounds naturally found in whole foods.

One of the hallmark features of UPFs is hyper-palatability, which is achieved through specific combinations of sugar, fat, salt, and artificial flavorings that stimulate reward pathways and encourage overconsumption. Additionally, the aggressive marketing strategies employed by multinational food corporations, particularly those targeting children and adolescents, further contribute to widespread consumption patterns.

The increasing dominance of UPFs within modern dietary environments has paralleled major changes in global nutritional habits. In numerous high-income countries, UPFs account for more than half of total daily caloric intake, while rapidly rising consumption has also been documented in middle-income and developing nations undergoing nutritional transition. These trends have raised substantial concerns

regarding the potential contribution of UPFs to obesity and related noncommunicable diseases.

Although the NOVA classification system has gained considerable acknowledgment within nutritional research, it has also been subject to criticism. Some researchers dispute that classification may oversimplify complex relationships between food processing and health outcomes by grouping nutritionally diverse products within the same category. Nevertheless, the NOVA framework remains highly influential in contemporary research investigating the health effects of industrial food processing.

### **3.2. Global consumption trends of UPFs**

Consumption of UPFs has increased dramatically across affluent and developing nations over recent decades. In several Western nations, daily dietary consumption is characterized by over 50% reliance on UPFs. Similar trends are increasingly observed in developing economies undergoing nutritional transition, where traditional dietary habits are progressively replaced by industrialized food products. Socioeconomic disparities also appear to influence UPF consumption patterns. Lower-income populations may rely more heavily on inexpensive ultra-processed products due to affordability, accessibility, and limited availability of healthier alternatives.

### **3.3. Biological mechanisms linking UPFs and obesity**

The following biological mechanism links UPFs and obesity:

a. Energy density and satiety- Ultra-processed foods are typically represented by high energy density and low satiety potential. Their soft texture, rapid oral processing, and high glycemic load may impair normal appetite regulation mechanisms, resulting in increased caloric consumption before satiety signals are activated.

b. Gut microbiota- emerging evidence indicates that eating habits rich in UPFs may adversely alter gut microbiota composition and diversity. Food additives such as emulsifying agents and artificial sweeteners have been associated with intestinal dysbiosis, increased gut permeability, and chronic low-grade inflammation, and all of these may contribute to obesity pathogenesis.

c. Neurobiological reward system- several studies suggest that hyper-palatable UPFs stimulate dopaminergic reward pathways in a manner comparable to addictive substances. Repeated exposure may reinforce compulsive eating behaviors and diminish sensitivity to natural satiety mechanisms.

### **3.4. Epidemiological evidence**

Numerous observational studies have persistently manifested a positive correlation between UPF consumption and obesity-related consequences. Large prospective cohort studies indicate that people with the highest UPF consumption exhibit significantly greater risks of weight gain, abdominal obesity, and metabolic syndrome compared with populations consuming minimally processed diets. Although most epidemiological findings support this association, several limitations should be acknowledged, including reliance on self-reported dietary assessments and heterogeneity in food classification methodologies.

### **3.5. Public health implications**

The widespread availability and aggressive marketing of UPFs represent substantial challenges for public health systems worldwide. Given the strong association between obesity and noncommunicable diseases, reducing UPF consumption may constitute an important strategy for mitigating healthcare burden and associated economic costs. Policy interventions including front-of-package labeling, taxation of sugar-sweetened drinks, constraints on food marketing directed toward children, and reformulation initiatives have demonstrated varying degrees of effectiveness in reducing unhealthy dietary behaviors.

### **3.6. Challenges and controversies**

Despite growing evidence linking UPFs to obesity, several controversies remain unresolved. Critics of the NOVA classification system argue that food processing itself may not necessarily determine health outcomes independently of nutrient composition. Furthermore, observational studies cannot fully exclude residual perplexing factors such as physical training, socioeconomic status, and overall dietary quality.

### **3.7. Future perspectives**

Future research should emphasize long-term randomized controlled studies capable of establishing causal relationships between UPF consumption and obesity development. Additionally, greater standardization of dietary assessment tools and food classification systems is required to improve comparability across studies.

## 4. DISCUSSIONS

The findings of this review reinforce the growing consensus that ultra-processed foods play a significant role in the global obesity epidemic. The convergence of epidemiological evidence and mechanistic insights suggests that UPFs contribute to excessive caloric intake, metabolic dysregulation, and long-term weight gain. Their hyper-palatability, affordability, and aggressive marketing—particularly toward susceptible groups, including children and economically disadvantaged populations, create powerful drivers of overconsumption.

At the same time, controversies surrounding the NOVA classification system highlight the complexity of disentangling the effects of food processing from nutrient composition. Some critics argue that not all UPFs are equally detrimental, and that reformulation strategies may mitigate health risks without requiring complete elimination. Furthermore, reliance on self-reported dietary data introduces measurement error, and residual bewildering factors such as physical training and socioeconomic rank complicate causal inference.

Despite these challenges, the public health implications are profound. With UPFs accounting for more than half of daily caloric intake in many high-income countries—and rapidly increasing in middle-income nations, the burden on healthcare systems is escalating. Policy measures such as front-of-package labeling, sugar-sweetened beverage taxation, restrictions on child-targeted advertising, and incentives for reformulation have shown promise but require broader implementation and evaluation.

Importantly, interventions must also consider cultural, economic, and social dimensions of food choice to ensure equitable access to healthier alternatives. Addressing the dominance of UPFs in modern diets will require coordinated action across governments, industry, and civil society to reshape food environments and promote sustainable, health-supportive dietary patterns.

## 5. CONCLUSIONS

In conclusion, the accumulated body of evidence strongly supports a strong correlation between ultra-processed food (UPF) ingestion and the global obesity epidemic. This relationship is underpinned by multiple biological, behavioral, and socioeconomic mechanisms, including impaired satiety signaling, alterations in gut microbiota, activation of neurobiological reward pathways, and the pervasive influence of aggressive marketing strategies. Together, these factors contribute to excessive caloric intake, metabolic dysfunction, and long-term weight gain across diverse populations.

The increasing worldwide dependence on industrially processed foods reflects profound transformations in global food systems, driven by urbanization, economic development, and globalization. While UPFs provide convenience and affordability, their dominance in modern diets has coincided with escalating rates of obesity and related noncommunicable diseases. This trend imposes substantial burdens on healthcare systems, economies, and societies, underscoring the urgency of coordinated preventive action.

At the same time, ongoing controversies—such as the debate over the NOVA classification system and the challenge of disentangling the effects of food processing from nutrient composition—highlight the need for methodological refinement and more robust causal evidence. Focus of future exploration should be on long-term randomized controlled studies to establish causality, alongside improved dietary assessment methodologies and standardized classification systems.

From a public health perspective, reducing UPF consumption must be recognized as a critical strategy in obesity prevention. Policy measures such as front-of-package labeling, taxation of sugar-sweetened beverages, restrictions on child-targeted advertising, and product reformulation initiatives have demonstrated promise but require broader implementation and rigorous evaluation. Importantly, interventions must also address socioeconomic disparities by ensuring equitable access to healthier, minimally processed alternatives.

Ultimately, tackling the global obesity epidemic will require a multifaceted approach that integrates scientific evidence, policy innovation, and societal engagement. By reshaping food environments and promoting sustainable dietary patterns, governments, industry, and civil society can collectively address the health consequences related to UPFs and foster a healthier future for populations worldwide.

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# ANATOMICAL AND MORPHOLOGICAL VARIATIONS OF THE BASILAR ARTERY ASSOCIATED WITH CEREBRAL CIRCULATION CHANGES

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**Abstract:** The basilar artery (BA) is one of the main vessels that supplies oxygen rich blood to the brain and it plays a very important role in cerebral circulation. It is formed by the union of the left and right vertebral arteries at the junction between the medulla oblongata and the pons, near the abducens nerve (CN VI)

The vertebrobasilar system is a major blood supply route to the posterior part of the brain, and variations in the basilar artery (BA) may affect blood flow and contribute to neurological symptoms or ischemic events.

**Aim:** This study aimed to assess how often anatomical variations of the BA occur according to sex and age, to measure BA diameter, and to evaluate their possible clinical relevance in patients with different neurological and traumatic conditions.

**Materials and Methods:** A retrospective study was conducted on 60 patients (25 women, 41.67% and 35 men, 58.33%) with a mean age of  $45.0 \pm 12.0$  years. Patients were examined at the Clinical Hospital Tetovo over a one-year period. CT, MRA, and Doppler ultrasound were used to evaluate the basilar artery. Measurements were taken and classified as normal, hypoplasia (<2 mm), or dolichoectasia (>4 mm). Data were analyzed using SPSS v26.

**Results:** Normal BA morphology was the most common finding in both sexes, especially in males (74.3%) compared to females (64%). Hypoplasia was more frequent in females (32%) than males (17.1%), while dolichoectasia was slightly more common in males (8.6%) than females (4%). In hypoplastic arteries, diameters ranged from 1.80 to 1.95 mm, while in dolichoectasia they exceeded 4.0 mm. Overall, the findings showed noticeable sex-related differences and were in line with previous studies.

**Conclusion:** Anatomical variations of the basilar artery are relatively common and may influence blood flow in the posterior circulation. Recognizing these changes early through modern imaging techniques is important for better diagnosis, risk evaluation, and clinical decision-making

**Keywords:** *Basilar artery, anatomical variations, cerebral circulation, vertebrobasilar system, posterior circulation infarction.*

**Field:** Medical Sciences and Health

## 1. INTRODUCTION

The vertebrobasilar system (VBS) is one of the main blood supply systems of the brain, providing oxygen-rich blood to the brainstem, cerebellum, thalamus, and occipital lobe. The basilar artery (BA) is formed by the joining of the left and right vertebral arteries and it represents the main artery of the posterior circulation [9,10]. Although its anatomy is usually described in a standard way, in real life there are often small natural variations.

These variations, such as hypoplasia, asymmetry, or dolichoectasia, are clinically important because they can change normal blood flow in the brain. Some people may never notice them, while in others they can lead to symptoms like dizziness, visual problems, imbalance, or even stroke. Hypoplasia means a smaller artery (usually <2 mm), while dolichoectasia refers to an enlarged and elongated artery (>4 mm). The basilar artery can also show different branching patterns, such as fenestration or unusual origins of cerebellar arteries. Even though these differences may seem small, they can affect blood flow and increase the risk of vascular complications in the posterior circulation. Because of this, recognizing these variations is very important in clinical practice. Modern imaging techniques like MRA and CTA help doctors detect them early and better understand patient risk.

The aim of this study was to analyze the frequency of anatomical variations of the basilar artery (BA) in relation to sex and age. In addition, the study sought to evaluate the diameter of the basilar artery and its potential influence on cerebral circulation, particularly in patients presenting with different clinical manifestations. Furthermore, the study aimed to compare the obtained findings with existing data from international literature in order to identify similarities, differences, and possible clinical implications.

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## 2. MATERIALS AND METHODS

In this retrospective observational study, 60 patients were analyzed, including 25 women (41.67%) and 35 men (58.33%), with a mean age of  $45.00 \pm 12.00$  years. Of the total number of patients ( $n = 60$ ), 33.3% were younger than 45 years, whereas 67.7% were older than 45 years. The patients were examined and hospitalized in the Department of Traumatology and Neurosurgery at the Clinical Hospital Tetovo during a one-year period. They were admitted for various conditions, including head injuries, neck injuries, traffic accidents, vertigo, and other neurological complaints, and were grouped according to sex and age. The patients underwent evaluation using Computed Tomography (CT), Magnetic Resonance Angiography (MRA), and color Doppler sonography. The analysis included measurement of the basilar artery diameter, as well as assessment for the presence of hypoplasia, dolichoectasia, and normal anatomical morphology. Our results were compared with data reported in internationally.

## 3. RESULTS

Descriptive statistical methods were used, including the arithmetic mean and standard deviation ( $X \pm SD$ ). Comparative statistics of lipid parameters between groups were analyzed using Student's t-test for independent and dependent samples, as well as non-parametric tests according to the Mann-Whitney U test. The results were processed using SPSS software version 26.

Table 1: Number of patients by gender and mean age  $\pm$  SD

Total number of patients	60 (100 %)	mean age $\pm$ SD
<b>Male</b>	<b>35 (58.33 %)</b>	<b>45.00<math>\pm</math>12.00 years</b>
<b>Females</b>	<b>25 (41.67 %)</b>	<b>45.00<math>\pm</math>12.00 years</b>

**Source:** The material presented in tables 1,2,3,4 and 5 was obtained from the records in the patient examination logbook in symptoms in the Departments of Traumatology and Neurology during the period from 11/2024 to 11/2025. The patients were diagnosed using CTM and Magnetic Resonance Angiography (MRA) in the Radiodiagnostics Department at the Clinical Hospital of Tetovo.

Table 2. Distribution of patients by age

Age	Men (n=35)	Wome(n=25)
<45 years	14 (40%)	10 (40%)
>45 year	21 (60%)	15 (60 %)

Table 3: Distribution of patients by symptoms and clinical picture

Symptoms	Number of patients (60-100%)
<b>Vertigo syndrome with cervical spondylosis</b>	<b>30 (50 %)</b>
<b>Essential hypertension</b>	<b>12 (20 %)</b>
<b>Vertebrobasilar ischemia</b>	<b>10 ((16.7 %)</b>
<b>TIA (Transient Ischemic Attack)</b>	<b>8 (13.3 %)</b>

The female population, normal morphology of the basilar artery was observed in 64% of patients, hypoplasia in 32%, and dolichoectasia in 4%. In the male population, normal morphology was present in 74.3% of cases, hypoplasia in 17.1%, and dolichoectasia in 8.6%. The mean arterial diameter in patients with hypoplasia ranged from 1.80 mm to 1.95 mm, while in the case of dolichoectasia it was 4.0 mm.

Table 4: Distribution of anatomical variations Basilar Artery in women

Anatomical Variations Female	Women	%
<b>Normal morphological anatomy</b>	<b>16</b>	<b>64.0</b>
<b>Hypoplasia</b>	<b>8</b>	<b>32.0</b>
<b>Dolichoectasia</b>	<b>1</b>	<b>4.0</b>
<b>Total</b>	<b>25</b>	<b>100</b>

Table 5: Distribution of anatomical variations in men

<b>Anatomical variations</b>	<b>Men (n)</b>	<b>%</b>
<b>Anatomical variations</b>	<b>26</b>	<b>74.00</b>
<b>Hypoplasia</b>	<b>6</b>	<b>17.10</b>
<b>Dolichoectasia</b>	<b>3</b>	<b>8.60</b>
<b>Total</b>	<b>35</b>	<b>100</b>

In the male sex, normal anatomical morphology was present in 26 patients (74.0%), hypoplasia in 6 patients (17.10%), and dolichoectasia in 3 patients (8.6%). In patients with hypoplasia, the diameter ranged between 1.80 mm and 1.95 mm, while in dolichoectasia it was over 4.0 mm.

#### 4. DISCUSSIONS

In our study, we found noticeable anatomical variations of the basilar artery (BA), with hypoplasia being the most common finding, especially in female patients. It was present in 32% of females compared to 17.1% in males, while dolichoectasia was more frequently observed in males (8.6%). These results are generally in line with published international studies, which suggest that variations in the vertebrobasilar system can influence blood flow in the posterior circulation and may be linked with ischemic changes. Even small differences in vessel shape and size can affect how blood moves through the brain and may contribute to reduced perfusion or vascular changes over time. In our study, we defined hypoplasia as a vessel diameter below 2 mm, and dolichoectasia as a diameter greater than 4 mm. who showed that dolichoectasia of the basilar artery increases the risk of posterior circulation stroke, especially in older patients, most likely due to disturbed and turbulent blood flow. Catalano et al. also pointed out that both congenital and acquired variations of the BA can be clinically important, as they are associated with conditions such as transient ischemic attacks, vertebrobasilar insufficiency, and ischemic stroke. In our sample, patients with hypoplasia had BA diameters between 1.80 mm and 1.95 mm, which is consistent with Chuang et al., who considered diameters below 2 mm as a relevant risk factor for posterior circulation events. Additionally, Hsu et al. reported an association between vertebral artery hypoplasia and acute ischemic stroke affecting the posterior circulation, while Dong et al. demonstrated through hemodynamic studies that structural variations of the basilar artery can significantly alter cerebral blood flow. Because our study did not include a control group, we compared our results with existing international literature in neuroangiography and radiology, and overall, modern imaging methods such as MRA and CTA remain essential tools for early detection and clinical evaluation of these vascular variations.

#### 5. CONCLUSIONS

Anatomical variations of the basilar artery (BA) are quite common and they can play an important role in how blood circulates in the brain, sometimes leading to disturbances in cerebral circulation. In many cases these variations may not cause any symptoms, but in others they can be associated with different neurological problems ranging from mild complaints to more serious deficits. Because of this, early detection is very important, and modern imaging techniques such as MRA and CTA have made it much easier to identify these vascular differences in routine clinical practice. Recognizing them in time helps clinicians better understand a patient's symptoms and reduces the risk of future cerebrovascular complications. Overall, variations of the BA and the vertebrobasilar system are not just anatomical findings, but clinically meaningful features that are important for diagnosis, prevention, and planning of both surgical and interventional treatment, as well as for predicting patient outcomes.

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