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Original Article

Observation of factors associated with visceral swallowing pattern in 2–6 year old children: A cross-sectional study<sup>☆</sup>Babak Sayahpour<sup>a,1</sup>, Magda-Anastasia Mylonas-Helbing<sup>b,2</sup>, Nicolas Plein<sup>a,1</sup>, Stefan Kopp<sup>a,1</sup>, Sara Eslami<sup>a,\*</sup>, Sarah Bühling<sup>a,1</sup><sup>a</sup> Department of Orthodontics, Goethe University Frankfurt, Theodor-Stern-Kai 7, 60596 Frankfurt am Main, Germany<sup>b</sup> Private Dental Office, Clemenstrasse 26-30, 56068 Koblenz, Germany

## ARTICLE INFO

## Keywords:

Deglutition  
Dyskinesia  
Orofacial  
Malocclusion

## ABSTRACT

**Introduction:** The association between the visceral swallowing pattern (VSP) and dentofacial abnormalities remains controversial. This cross-sectional study aimed to investigate the association between the VSP and various factors including type of birth, gender, tongue posture, lip incompetence, eruption of primary molars, habits and the presence of malocclusions in children with primary and early mixed dentition.

**Material and method:** A total of 219 children (102 boys and 117 girls) were evaluated using a combination of a questionnaire and a structured clinical examination by one pediatric specialist dentist. Kittel's method of tongue posture evaluation and the Payne technique for assessment of swallowing pattern were included in the clinical examination of myofunctional status. After checking for normality, normal and non-normal distributed data were analyzed using two-sample *t*-test and Mann-Whitney *U* test, respectively. Analysis of categorical variables was done using a chi-square test, and Bonferroni correction was used as correction for multiple comparisons.

**Results:** A total of 56.2 % of the study population had a VSP. The chi-square test indicated a statistically significant higher presence of VSP in male gender. Statistically significant associations were seen between the VSP and lip incompetency, pathologic resting tongue position, habits, anterior open bite and increased overjet. On the other hand, no statistically significant associations were found between VSP and children's age within the sample population, type of birth, uni- or bilateral crossbites, increased overbite, edge-to-edge anterior bite or completion of eruption of primary molars and/or permanent incisors.

**Conclusions:** The association between VSP and male gender, pathologic tongue posture, lip incompetency and habits and occlusal traits such as anterior open bite and increased anterior overjet is supported by the results of the present study.

## 1. Introduction

Infantile or visceral swallowing pattern (VSP) is a physiological process that is characterized by the forward movement of the tongue against or between the incisors during the swallowing process (Goncalves et al., 2023). This type of swallowing pattern is present at birth and typically persists until the eruption of the primary molars. Any persistence of the VSP beyond this point is considered an abnormality (Silva and Manton, 2014).

Several authors have shown that malfunctions of the orofacial muscles can lead to deformities (Goncalves et al., 2023; Ling et al., 2018; Grippaudo et al., 2016; Hanna et al., 2015; Cenzato et al., 2021; Silva and Manton, 2014). Orofacial myofunctional therapy has been advocated to restore the myofunctional balance of the orofacial complex and prevent the development or progression of these deformities (Shah et al., 2021). However, some researchers have failed to establish a causal relationship between muscular dyskinesia and the development of orofacial deformities. Some argue that dyskinesia such as VSP has been

<sup>☆</sup> This manuscript is derived from a dissertation at the orthodontic department of Johann-Wolfgang Goethe University.

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<https://doi.org/10.1016/j.sdentj.2024.01.001>

Received 1 August 2023; Received in revised form 21 December 2023; Accepted 1 January 2024

Available online 3 January 2024

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overemphasized, and that resting tongue position as well as genetic factors have a more important role (Mason and Proffit, 1974). Nevertheless, many experts recommend early detection and management of orofacial dysfunctions to prevent the development or progression of orofacial deformities (Cenzato et al., 2021).

The controversy surrounding the role of VSP might arise from the varying methods of assessing swallowing pattern, leading to inconsistencies in research findings (Ovsenik et al., 2014; Mehnert et al., 2009a; Rivera-Torres, 1992; Gorurgoz et al., 2022; Botero-Mariaca et al., 2018; Bell and Hale, 1963; Volk et al., 2010; Mehnert et al., 2009b). Clinical evaluation of oral dyskinesia in young children is challenging and the examination methods often yield unsatisfactory agreement. For instance, the observational method has been criticized for potentially interfering with the swallowing pattern (Peng et al., 2004). Radiation-based methods (Fujiki et al., 2004) are not considered appropriate for young children, while newer techniques such as MRI and ultrasound are costly and not yet standardized (Mehnert et al., 2009a, Peng et al., 2004).

Despite these challenges, certain authors have reported a relationship between VSP, tongue position and specific malocclusions, such as mandibular prognathism, anterior open bite, posterior crossbite and excess overjet (Cenzato et al., 2021; Stahl and Grabowski, 2003; Grabowski et al., 2007).

Furthermore, the evidence on the relationship between orofacial dysfunctions such as VSP and other factors such as type of birth, gender, age and tongue resting position is controversial.

Therefore, the present study aimed to evaluate the association of VSP with possible factors such as gender, specific malocclusions and habits in young children using a combination of a questionnaire and a modified Payne method of swallowing pattern examination.

## 2. Materials and methods

The clinical cross-sectional study received ethical approval from the Johann Wolfgang Goethe University Ethics Committee in Frankfurt am Main. Written informed consent was obtained from parents or legal guardians of participants.

### 2.1. Inclusion and exclusion criteria

Healthy 24- to 83-month-old children were included. Those with systemic diseases, syndromes, conditions such as cleft lip and palate, craniofacial deformities or a previous or ongoing orthodontic or myofunctional therapy as well as those with low compliance with the clinical examination were excluded.

### 2.2. Patient recruitment and evaluation

A total of 219 children (102 girls and 117 boys) with an average age of 48 months were recruited from a private pediatric dental office during their scheduled dental check-ups between May 2020 and May 2021.

The assessment was conducted in a single session and involved the completion of a questionnaire with the parents, followed by a clinical examination of the children conducted by a single experienced pediatric specialist.

### 2.3. Questionnaire

A questionnaire based on Bigenzahn was employed (Korbmacher et al., 2004). The questionnaire encompassed various aspects, including the age and gender of the children as well as inquiries regarding the mode of delivery during birth, primary form of nutrition and details pertaining to habits such as type, duration and onset.

### 2.4. Clinical examination

Clinical examination consisted of dental, orthodontic and functional evaluations of the children in the presence of their parents.

#### 2.4.1. Dental examination

The children's dental health and dental developmental stage (primary or early mixed dentition) were recorded.

#### 2.4.2. Orthodontic examination

##### 1- Anterior overjet:

Anterior overjet was assessed using an intra-oral ruler, measuring the distance in millimetres between the labial surface of the lower incisors and the palatal surface of the upper incisors. Overjet values ranging from 0 mm to 2 mm were considered normal, whereas values exceeding 2 mm, at 0 mm or below 0 mm were classified as increased, an edge-to-edge anterior bite and anterior crossbite, respectively.

##### 2- Sagittal posterior occlusion:

The classification of occlusion was based on the positioning of the primary canines or first permanent molars in children with primary dentition or mixed dentition, respectively.

##### 3- Transversal posterior occlusion:

The presence of uni- and bilateral crossbites was recorded.

##### 4- Anterior overbite:

An overlapping of the lower incisors by the upper incisors within a range of up to 2 mm was considered normal, whereas an overlapping beyond two-thirds of the lower incisors or negative values indicated a deep bite or an open bite, respectively.

#### 2.4.3. Functional evaluation

Complete and unstrained lip closure was considered lip competency, while slightly or extremely open lips and hyperfunction of the mentalis muscle upon lip closure were classified as lip incompetence.

The evaluation of tongue resting position was conducted using Kitzel's method (Ovsenik et al., 2014). A physiologic resting position was defined as the tongue being in contact with the palate. An interdental position or a low tongue position was considered pathological.

The evaluation of swallowing pattern was conducted using a modified version of the Payne technique (Rivera-Torres, 1992). Initially, the children were instructed to protrude their tongues, and any excess saliva was gently removed using gauze. Edible food coloring (Wusitta, Erich Wutzig, Germany) was then applied to the tip, lateral, and anterior borders of the tongue. Children were instructed to swallow only once and then open their mouths. The remaining food coloring revealed the contact points between the tongue and other oral structures, which were visualized for the classification:

- 1- Somatic swallowing pattern (SSP): If color was observed on the papilla incisive (located behind the upper anterior teeth), the anterior region of the hard palate slightly behind the upper anterior teeth and the lateral palatal mucosa around the gingival margin of primary molars.
- 2- Visceral swallowing pattern (VSP): If coloring remnants were found on the palatal surface of the upper incisors, lingual surface of the lower incisors, incisal edges of the upper incisors or inner surface of the upper lip.

2.5. Statistical analysis

Sample size calculation was done based on a previous study (Hanna et al., 2015), which resulted in a medium effect size of 0.215. Therefore, a sample size of 208 children was required to achieve a test power of 80 % at an alpha of 0.05. Considering a potential dropout rate of approximately 5 % due to lack of compliance with the clinical examination, 219 children were recruited for this study.

The normality of data distribution was assessed using the Shapiro-Wilk test. Comparisons of normally distributed data were conducted using the two-sample *t*-test. Non-normally distributed data were analyzed using the Mann-Whitney *U* test. The analysis of categorical variables was performed using the chi-square test. A significance level of  $p < 0.05$  was set for all tests. Bonferroni correction was used to adjust the significance level to control for multiple comparisons.

The statistical analysis was conducted using BiAs software version 11.12 (epsilon-Verlag GbR, Germany).

3. Results

A total of 219 children, consisting of 102 boys and 117 girls, were included in this study. Ninety-six children (43.8 %) exhibited an SSP, while 123 children (56.2 %) demonstrated a VSP. Table 1 presents an overview of the data on the participants, including their age-based subgroup distribution. Correlation analysis was conducted to investigate the relationship between the presence of a VSP and other factors (Table 1).

VSP was observed in 48.7 % of girls and 64.7 % of boys. The chi-

**Table 1**  
Prevalence of VSP in the study population regarding the associated factors.

	Total (n = 219)	SSP (n = 96)	VSP (n = 123)	p-value
<b>Gender</b>				0.024956**
Male	102	36	66	
Female	117	60	57	
<b>Age</b>				0.282116
23–35 months	51	16	35	0.330191
36–47 months	61	29	32	0.040172**
48–59 months	52	27	25	0.410736
60–71 months	33	15	18	1.000.000
72–84 months	22	9	13	1.000.000
<b>Type of birth</b>				0.530317
Natural delivery	145	66	81	
Caesarean section	72	30	102	
<b>Habits</b>				0.035634**
Pacifier	161	63	98	
Thumb sucking	16	8	8	
Others	4	2	2	
None	38	23	15	
<b>Lip competency</b>				0.000033**
Competent	161	85	76	
Incompetent	58	11	47	
<b>Tongue resting posture</b>				0.000000**
Physiologic	159	92	67	
Pathologic	60	4	56	
<b>Dental status</b>				0.378375
Incomplete primary dentition	25	10	15	
Complete primary dentition	194	86	108	0.844195
Early mixed dentition	21	6	15	0.331421
<b>Occlusion</b>				0.000000**
Neutral occlusion	119	76	43	
Anterior open bite	41	0	41	0.000000**
Cross bite	9	2	7	0.034459**
Deep bite	10	9	1	0.184477
Increased overjet	36	7	29	0.000007**
Anterior edge-to-edge bite	4	1	3	0.291493
<b>Dental health</b>				0.503910
Caries free	187	83	104	
Restored	21	10	11	
Carious	11	3	8	

square test indicated a statistically significant correlation between the male gender and the presence of a VSP ( $p < 0.05$ ). However, when dividing the participants into age subgroups, this significant correlation was found to be present only in the 36- to 47-month age group.

Furthermore, the presence of a VSP exhibited a significant correlation with lip incompetency ( $p < 0.05$ ). Among participants with lip incompetency, 81 % demonstrated a VSP. However, 47 % of participants with lip competency also displayed a VSP. Significant associations were also found between the VSP and pathological resting position of the tongue ( $p < 0.05$ ).

In relation to occlusal traits, the analysis revealed a statistically significant correlation between the VSP and two in particular: anterior open bite and increased anterior overjet ( $p < 0.05$ ). However, after applying the Bonferroni correction, no statistically significant correlation was observed between the VSP and the presence of posterior uni- or bilateral crossbite, increased overbite or edge-to-edge anterior bite.

Analysis of the habit data revealed that only 17.3 % of participants reported a complete lack of habits. The majority of participants reported various sucking habits, including the use of pacifiers (73.97 %), thumb sucking (7.3 %) and other habits (0.14 %). A chi-square test showed a significant association between the presence of habits and the VSP ( $p < 0.05$ ).

No significant association was found between the type of birth or the children’s age and the presence of a VSP in the study population.

Furthermore, no significant correlations were recorded between different subdivisions in age, the completion of primary molar or permanent incisor eruption and SSP.

4. Discussion

Our results showed statistically significant associations between the presence of VSP and factors such as gender, lip incompetency, pathological resting position of the tongue, anterior open bite and increased anterior overjet ( $p < 0.05$ ).

The evaluation of swallowing patterns has been approached using various methods (Ovsenik et al., 2014; Mehnert et al., 2009a; Peng et al., 2004; Volk et al., 2010; Mehnert et al., 2009b). However, a comparison between Kittel’s method of visual inspection and MRI examination of tongue resting positions and swallowing patterns has revealed significant discrepancies between these two methods (Mehnert et al., 2009a). The question of which method offers greater accuracy, remains unclear. During visual inspection of the tongue at its resting position or during swallowing, the clinician’s fingers exert force on the lips and cheeks. This external force influences tongue posture (Peng et al., 2004). This method has also been associated with high heterogeneity. Therefore, we have also incorporated the Payne technique of evaluation, which is non-invasive, easy and low-cost (Rivera-Torres, 1992). This method is shown to have similar results to cineradiography and can be considered a reliable method of swallowing assessment, as it does not interfere with unconscious swallowing (Gutierrez et al., 2021).

No significant association was found between age and presence of VSP in the age-based subdivisions of our population. Our sample included children between the ages of 2 and 6 years old. A similar study that examined the relationship between age and VSP observed a decrease in VSP as age increased. However, this study utilized a sample with a slightly older range between 5 and 8 years of age (Van Dyck et al., 2016).

While some reports have suggested a transition from a VSP to a somatic pattern after the eruption of primary molars or permanent incisors, our study did not find any significant correlations between these factors.

The association between gender and VSP also remains controversial. Some studies, such as the one conducted by Stahl et al., report no gender-specific correlation (Stahl and Grabowski, 2003). However, other investigators have reported a higher prevalence of speech distortion and abnormal swallowing pattern in boys (Butler et al., 1973).

Furthermore, a higher association of the male gender with speech distortion and reduced tongue mobility may be attributed to gender differences in brain maturation rates. Our findings demonstrate a higher prevalence of the visceral swallowing pattern in the male population. However, it is important to note that this association was primarily observed in children aged between 36 and 47 months. This suggests that gender difference in swallowing patterns may vary across different age groups, as we found no association between gender and swallowing pattern in children younger than 3 years or older than 4 years of age.

A substantial proportion (73.4 %) of our study population reported the use of pacifiers, and we found a significant association between the presence of habits and VSP. These findings are consistent with previous studies.

The causality of habits on abnormal swallowing patterns and malocclusions has been a subject of debate (Zadik et al., 1977; Larsson, 2001; Duncan et al., 2008; Modeer et al., 1982; Melsen et al., 1979; Melsen et al., 1987; Larsson, 1983; Larsson and Dahlin, 1985; Xu et al., 2023; Larsson, 1985; Caruso et al., 2019; Silva and Manton, 2014; Vaidergorn, 1991). However, a considerable number of authors concur that the effects of non-nutritive sucking habits, such as pacifier use, can be reversible if they are discontinued at an early age, typically before 3 or 4 years (Larsson, 2001; Duncan et al., 2008; Silva and Manton, 2014).

The association between VSP and malocclusions in primary and mixed dentitions remains controversial. Previous studies have reported associations between the VSP and anterior open bite, increased anterior overjet and posterior crossbite (Melsen et al., 1979; Melsen et al., 1987; Stahl et al., 2007; Grabowski et al., 2007; Cenzato et al., 2021; Van Dyck et al., 2016; Germa et al., 2016; Grippaudo et al., 2016; Goncalves et al., 2023; Gutierrez et al., 2021).

We observed significant correlations between the VSP and anterior open bite as well as increased anterior overjet. However, our results did not demonstrate any association between atypical swallowing patterns or the presence of uni- or bilateral crossbite. These results suggest that, while non-nutritive sucking behaviors and habits play a role in the occurrence of crossbites, the association with VSP may be more of an accompanying factor rather than a primary etiological factor (Grippaudo et al., 2016). It is also noteworthy that 36 % of the participants who showed a neutral occlusion with physiologic overbite and overjet had a VSP.

The employment of the Payne technique as a reliable method of swallowing assessment is one of the deciding strengths of the present study, whereas the small sample size and homogeneity as well as the cross-sectional design of our study should be acknowledged as limitations. Consequently, future prospective longitudinal studies with larger sample sizes and greater heterogeneity in their samples are warranted to further investigate these findings.

## 5. Conclusion

The following can be concluded within the limitations of this cross-sectional study:

- 1- VSP is associated with male gender (within the 36- to 47-month age group), pathologic tongue posture, lip incompetency, habits and occlusal traits such as anterior open bite and increased anterior overjet.
- 2- No statistically significant correlations were found between VSP and type of birth, the age of the children within the study population of 2–6 years or the completion of primary molar or permanent incisor eruption.

## CRedit authorship contribution statement

**Babak Sayahpour:** Conceptualization, Methodology, Supervision. **Magda-Anastasia Mylonas-Helbing:** Methodology, Investigation, Resources. **Nicolas Plein:** Formal analysis, Visualization. **Stefan Kopp:**

Conceptualization, Supervision, Project administration. **Sara Esلامي:** Formal analysis, Writing – original draft, Writing – review & editing. **Sarah Bühling:** Project administration, Methodology, Supervision.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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