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ORIGINAL RESEARCH

Comparison of signs and symptoms of temporomandibular disorders and parafunctions in children with and without cardiovascular diseases

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Abstract

Aim: This study aimed to examine and compare the signs and symptoms of temporomandibular disorders (TMDs) and oral parafunctions in pediatric patients with and without cardiovascular diseases (CVDs). Study Design: A total of 295 children with CVD (the CVDG group) admitted to the Cardiology Department and another set of 295 children without CVD (the CG group) were included in this study. All children were 6–18 years old. This study was conducted in 2 stages, comprising a questionnaire (symptoms/parafunctional habits) and a temporomandibular joint examination (signs) based on the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD). The data obtained were evaluated statistically. Results: The two groups showed no significant difference in the prevalence of TMD symptoms/signs or parafunctional habits ($p > 0.05$). Although the anamnestic symptoms related to pain were lower in the CVDG group, the clinical examination results were similar in terms of pain findings between the two groups. Both anamnestic and clinical findings showed higher "joint noise" and "deviation" in the CVDG group ($p < 0.05$). With regard to parafunctional habits, "fingernail biting" and "bruxism", were higher in the CVDG group than in the CG group. Conclusion: The prevalence of TMDs and oral parafunctions did not vary between children with and without CVD. However, a significant relationship was observed between the symptoms/signs of TMDs, parafunctional habits and the presence of CVD in children.

Keywords

Children; Temporomandibular diseases; Cardiovascular diseases; Parafunctional habits

1. Introduction

Oral health is multifaceted and includes several concepts such as speaking, smiling, smelling, tasting, touching, chewing, swallowing and conveying a spectrum of emotions *via* facial expressions with confidence and without any pain, discomfort, or diseases related to the craniofacial complex [1]. Oral health is an integral part of general health, with increasing evidence showing their relationships in different fields, such as all areas of dentistry, including pediatric dentistry [2]. Cardiovascular diseases (CVDs) are the leading systemic diseases, and numerous research have reported a strong link between them and oral health [3]. Children with cardiac conditions usually have a long history of oral caries compared with healthy and matching control subjects [4], possibly related to higher decayed, missing and filled teeth index scores, as well as having substantially more advanced carious lesions that have not been treated in both the primary and permanent teeth [5].

CVDs may negatively affect oral health due to increased developmental enamel defect rates in pediatric patients. Additionally, long-term consumption of sugary products and parents' neglect of oral health checks are also common predisposing factors [6]. Dental bacteremia can lead to various conditions, such as infective endocarditis, and pediatric patients undergoing general anesthesia due to several surgical operations are at increased risk for prolonged bleeding due to warfarin treatment [7]. Hallett *et al.* [8] found that despite similar living environments, children with CVDs had significantly more teeth with untreated dental decay and more endodontically treated teeth than healthy control siblings. Additionally, they found that the CVD patients had approximately twice the number of affected teeth and a significantly greater prevalence of developmental enamel defects than their siblings.

Temporomandibular joint (TMJ) health is an important part of oral health [9], and its deterioration can lead to TMDs, which represent a collective term for clinical complaints involving mastication muscles, TMJ or associated oral-facial structures [9]. The most common clinical symptoms are hearing noise during mouth opening and closing movements, limitation in mandibular movements, TMJ and muscle tenderness, as well as headache, facial pain, bruxism and strain when opening the mouth [10]. Although TMDs are frequently seen in adults, many studies have shown that their symptoms originate from childhood [11]. Nilson *et al.* [12] concluded that the presence of TMD pain in adolescents tripled the risk of TMD pain in young adulthood, and the presence of persistent pain increased comorbid pain and psychosocial distresses. A review of several epidemiological studies showed that the prevalence rate of TMD in children and adolescents ranged from 9.8% to 80% [13].

Although many conditions, such as parafunctional habits, sex, acute trauma, degenerative joint disorders and immunological factors, are reported as etiologies of TMDs, psychophysiological problems are considered the most significant etiology [14]. Psychophysiological factors include psychological and behavioral disorders such as somatization, stress, anxiety and depression. Stress-induced parafunctional movements such as teeth clenching and grinding, bruxism (particularly during sleep), constant biting or chewing of foreign objects and lip biting or sucking could lead to nonfunctional movements of TMJ that damage the surrounding joint tissues over time [11, 14]. In children with heart disease, related treatments and insufficient oral care might be predisposing factors leading to the development of psychophysiological problems [4, 5, 14] and TMD. Since TMJ-related deformations are generally irreversible, early diagnosis of the symptoms is of great importance to eliminate predisposing factors and the progression of the disease [12].

To the best of our knowledge, the prevalence of signs and symptoms of TMDs and oral parafunctions in children with CVD has not been previously evaluated. Thus, this study aimed to compare the signs and symptoms of TMD, including those involving TMJ and surrounding tissues, between children with CVD and without CVD.

2. Materials and methods

A preliminary statistical analysis was performed to determine the number of individuals to be included in this cross-sectional study. Based on the data from a previous study [15], a minimum sample size of 283 subjects per group was computed using the G*Power software (Ver. 3.1.9.2). Differences between two independent proportions were used for the calculation. Type I error (alpha) and power (1-beta) were considered to be 0.05 and 0.95, respectively. Considering the possibility of dropouts, this study had to enroll 295 children per group. Thus, 295 children aged 6–18 with congenital or acquired CVD treated at the Department of Pediatric Cardiology of the KOU Faculty of Medicine were included in this study and formed the research group (CVDG). Necessary permissions were obtained from the director of the Department of Pediatric Cardiology (KOU Faculty of Medicine) to conduct this study. The families of the children were informed about the aim of the study, and all gave their written consent. Additionally, written consent was obtained from the children. To form the healthy control group (CG), 295 children of similar ages who were students from 1 primary school, 2 elementary schools and 2 high schools in Kocaeli and did not have any systemic disease were also included. Since children with mixed socioeconomic levels were sought, private schools were not included in this study. Three different levels of public schools in the center of the city were included in this study to ensure different age groups after obtaining permission from education-related government officials. The selection of children was performed randomly by choosing them from class lists using computer-generated random numbers (Research Randomizer Software). To maintain homogeneity between the study groups, we tried to match their age and sex distribution as far as possible. Similar to CVDG, the parents and children of the CG group were informed about the objectives of this study and their written consent was obtained. Those who did not give consent were not included.

Additionally, in the CVDG, patients who had any systemic disease other than CVD, any signs of intellectual disability, CVD-related syndromes or were non-cooperative were not included. In the CG, patients with systemic diseases, intellectual disabilities or unwillingness to abide by this study protocol were excluded. This study was performed in two stages for both groups. Stage 1 included a questionnaire review using the questions in the TMD evaluation guideline of the American Academy of Pediatric Dentistry (AAPD) for infants, children and adolescents [16], while stage 2 comprised TMJ examination based on the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) [17]. Data from CVDG were obtained in a quiet room reserved for research in the Pediatric Cardiology Department. For the control group, the data were obtained in the school nurse's office. The children were examined while sitting in an upright position on a regular chair. Clinical examinations were conducted by a single examiner who was an experienced pediatric dentist and blinded to the findings of the self-reported data (questionnaire and symptoms). Before the examinations, the researcher was trained by an orofacial pain specialist. Additionally, calibration was previously conducted as a pilot study in which 40 children were reviewed for a routine dental checkup at the KOU Pediatric Dentistry Clinic. The children were clinically examined, and 20 were re-examined [15, 18] to calculate intraexaminer reliability. Cohen's kappa (κ) coefficient showed excellent reliability ($\kappa > 0.81$). Furthermore, the questionnaire was administered to the same children before the clinical examination, and their responses were evaluated for clarity and comprehensibility.

The questionnaire was based on the following topics:

1. Sociodemographic variables:

a. Age

b. Sex

2. Oral parafunctions (daily occurrence) [15–17]

a. Biting of fingernails

b. Biting of hard objects (pencil, pen, *etc.*)

c. Crushing of ice, hard candies, popsicles, *etc.*, using teeth/Dismantling of toys/games using teeth/Opening bottles with teeth

d. Chewing gum

e. Bruxism (diurnal teeth grinding/clenching)

f. Jaw play (involuntary small mandibular movements without tooth contact)

3. TMD symptoms (occurring at least once weekly during the past three months) [15–17]

a. Pain or tiredness in facial muscles during activities such as chewing, talking or any activity involving the jaw

b. Pain around the TMJ

c. Joint sticking (sudden or momentary) and self-releasing locking of the jaw that prevents the jaw from being fully opened or the feeling that the jaw may be stuck and cannot be released with ease

d. Joint noises (clicking, popping or grating) during jaw movement

e. Difficulty in opening the mouth

The clinical examination [16, 17, 19] of each child was performed on the same day the questionnaire was completed and consisted of TMD signs, including the following:

1. Joint tenderness: The examiner palpated the joints bilaterally by placing the fingertips simultaneously on the lateral poles of the condyles.

2. Masticatory muscle tenderness: The examiner palpated the masseter, temporalis, sternocleidomastoid, and posterior cervical muscles with her fingers to detect tenderness.

3. Deviation: Deviation was evaluated with the mandible moving away from the midline and then returning to the center in a "C" or "S" pattern.

4. Subluxation: If the TMJ locked in an open mouth position (dislocation) could be reduced to normalize jaw movement by the patient with a manipulative maneuver, this is referred to as subluxation.

5. Joint sounds: The examiner recorded "clicking" (*i.e.*, a single sound with a short duration) and "crepitation" (*i.e.*, multiple grating sounds) when they were clearly audible. Additionally, she placed her fingertips on the lateral surface of the joint and tried to feel and hear the sounds during the process of mouth opening and closing.

6. Mouth opening: The examiner measured the distance between the incisal edge of the maxillary and mandibular incisors with any vertical overlap that may be present by using an orthodontic ruler and determined the maximum vertical opening of the mouth. In this study, a distance $<$30 mm was recorded as restricted opening [15–19].

Statistical analyses were conducted using the SPSS software (v20.00; IBM, Chicago, IL, USA). Intrarater reliability was analyzed using the Kappa test value (κ), with values of $>$0.81, 0.80–0.61, 0.60–0.41, 0.40–0.21, and $<$0.20 denoting excellent, substantial, moderate, fair, and slight agreement, respectively. The differences in TMD signs and symptoms and the differences in oral parafunctions between the study groups were analyzed using the chi-square test. The effects of sex and the presence of parafunctional habits on TMD signs and symptoms were assessed using binary logistic regression analysis. For all cases, the significance level was set at $p <$ 0.05.

3. Results

In this cross-sectional study, TMD signs and symptoms, parafunctional habits and their association were investigated among the 590 investigated children, who were grouped into CVDG (n = 295) and CG (n = 295) based on the presence of an underlying CVD. The distribution of the participants according to their sex, age, and dentition status is shown in Table 1.

Table 2 shows the distribution of TMD symptoms and signs among children with both mixed and permanent dentition. The results showed that the prevalence of TMD symptoms and signs was similar between CVDG and CG, with 49% of children in CVDG showing at least one TMD symptom and 87% showing at least one TMD sign, compared with 45% and 80% in CG with permanent dentition, respectively (Table 2). The most reported symptom by the children in both groups was "joint noises" and its prevalence was higher in CVDG. However, a statistically significant difference was observed for joint noises only among children with permanent dentition between the two groups (Table 2). Additionally, although reported pain symptoms were higher in CG than in CVDG, they were significantly different only among children with primary dentition (Table 2).

During the clinical examination, the most commonly recorded sign was "muscular tenderness" in both groups (Table 2). The rate of muscle tenderness in CVDG was 58% and 71% and was 71% and 65% in CG among children with mixed and permanent dentition, respectively. A significant difference in muscle tenderness between CVDG and CG was only found among children with primary dentition ($p <$ 0.05). The most observed clinical signs following muscle tenderness in both groups were "deviation" and "clicking". The prevalence of "clicking" was significantly higher in CVDG than in CG among children with mixed and permanent dentition ($p <$ 0.05). In addition, a significantly higher rate of deviation was found among children with permanent dentition in the CVDG compared with CG ($p <$ 0.05) (Table 2).

The distribution of parafunctional habits among children with mixed and permanent dentition in both groups is shown in Table 2. Overall, at least 1 parafunctional habit was found in 87% and 86% of children with primary dentition in CVDG and CG. Similar results were observed among children with permanent dentition. The parafunctional habits showed significant differences between CVDG and CG in regard to "fingernail biting", "gum chewing" and "bruxism". Comparatively, "fingernail biting" and "bruxism" were higher in CVDG than in CG, while the incidence of "gum chewing" was higher in CG than in CVDG among children of both dentition statuses (Table 2).

Table 3 and Table 4 show the results of binominal regression analysis for evaluating the effects of sex and parafunctional habits on TMD signs/symptoms. Although no statistically significant relationship was observed between TMD symptoms and sex or the presence of parafunctional habits ($p <$ 0.05), all symptoms except joint sticking were significantly related to CVD (Table 3).

Similar to the TMD symptoms, no relationship was found between all TMD findings and the presence of oral parafunctional habits ($p >$ 0.05). However, sex differences could pose a risk in terms of muscular tenderness. In addition, a significant relationship was found between "deviation" and "joint noise" with the presence of CVD in children (Table 4).

4. Discussion

This study showed that the signs and symptoms of TMDs and oral parafunctions did not vary significantly between children with and without CVD. However, clinical findings and some parafunctional habits were more prevalent among children

TABLE 1. Sample characteristics of the study (n = 590).

Variable	Children with cardiovascular disease	Children without cardiovascular disease
Gender (girls/boys)	148/147 (50.2/49.8)	147/148 (49.8/50.2)
Age	6–11 years/12–18 years 141/154 (23.9%/26.1%)	6–11 years/12–18 years 138/157 (23.4%/26.6%)

Values are given as n (%) or mean ± standard deviation.

TABLE 2. Anamnestic (symptoms) and clinical findings (signs) of TMD and parafunctional habits.

	Mixed Dentition (n = 279)		Permanent Dentition (n = 311)		*p* Values
	CVDG (n = 141) (n/%)	CG (n = 138) (n/%)	CVDG (n = 154) (n/%)	CG (n = 157) (n/%)	
Symptoms					
Pain or tiredness in the masticatory muscles	3 (2.1%)	16 (11.6%)	9 (5.8%)	27 (17.2%)	0.030*/0.040*
Pain around the TMJ	9 (6.4%)	12 (8.7%)	8 (5.2%)	34 (21.7%)	0.464/0.000*
Reported joint noise	26 (13.8%)	19 (18.4%)	57 (37%)	40 (25.5%)	0.185/0.019*
Joint sticking	2 (1.4%)	4 (2.9%)	25 (16.3%)	15 (9.6%)	0.394/0.053
Difficulty in mouth opening	6 (4.3%)	8 (5.8%)	3 (1.9%)	14 (8.9%)	0.555/0.007*
No Symptom	102 (72.3%)	95 (68.8%)	78 (50.6%)	86 (54.8%)	0.501/0.466
Signs					
Musculer tenderness	82 (58.2%)	98 (71.2%)	110 (71.4%)	102 (65%)	0.025*/0.318
TMJ tenderness	3 (2.1%)	0	0	1 (0.6%)	0.085/0.321
Deviation	37 (21.7%)	30 (26.2%)	81 (52.6%)	58 (36.9%)	0.379/0.040*
Subluxation	2 (0.7%)	0	11 (7.1%)	9 (5.7%)	0.879/0.373
Joint sounds (Clicking)	35 (24.8%)	21 (15.2%)	71 (46.1%)	52 (33.1%)	0.045*/0.019*
No Sign	48 (34%)	34 (24.6%)	20 (13%)	31 (19.7%)	0.085/0.108
Parafunctional Habits					
Biting Fingernail	60 (42.6%)	32 (23.2%)	59 (38.3%)	31 (19.3%)	0.000*/0.010*
Biting Pencil	19 (13.5%)	15 (10.9%)	29 (18.8)	25 (15.9%)	0.506/0.499
Chewing ice/opening bottle	17 (12.1%)	23 (16.7%)	21 (13.6%)	31 (19.7%)	0.319/0.149
Clenching/grinding teeth	44 (31.2%)	22 (15.9%)	40 (26.0%)	32 (20.4%)	0.030*/0.242
Jaw play	15 (10.9%)	15 (10.6%)	34 (22.1%)	20 (12.7%)	0.950/0.061
Chewing Gum	16 (11.3%)	88 (63.8%)	44 (14.1%)	82 (26.4%)	0.000*/0.000*
No habit	19 (13.5%)	19 (13.9%)	23 (14.9%)	20 (12.7%)	0.943/0.575

*CVDG: Children with cardiovascular disease; CG: Children without cardiovascular disease; TMJ: Temporomandibular joint. *Significant difference according to the chi-square test (p < 0.05).*

TABLE 3. Binary logistic regression summary for the symptoms of TMD and variables (girl/boy, with or without CVD and having oral parafunctional habits).

Variable	B (SE)	Wald	Sig	OR (95% CI)
Symptoms				
Muscle pain				
Gender^c	0.118 (0.289)	0.166	0.684	1.125 (0.638–1.983)
OH^a/OH^b	−0.163 (0.609)/−0.399 (0.459)	0.071/0.755	0.789/0.385	0.850 (0.258-2.804)/0.671 (0.273–1.650)
Group^d	1.386 (0.338)	16.816	0.000*	4.001 (2.062–7.761)
TMJ Pain				
Gender^c	0.101 (0.271)	0.140	0.708	1.107 (0.651–1.882)
OH^a/OH^b	−0.006 (0.550)/−0.207 (0.406)	0.000/0.260	0.992/0.610	0.994 (0.338–2.921) /0.813 (0.367–1.803)
Group^d	1.100 (0.297)	13.714	0.000*	3.006 (1.679–5.381)
Joint Noise				
Gender^c	−0.069 (0.194)	0.127	0.721	0.933 (0.638–1.365)
OH^a/OH^b	0.295 (0.355)/0.355 (0.263)	0.691/1.828	0.406/0.176	1.343 (0.670–2.690)/1.426 (0.852–2.386)
Group^d	−0.445 (0.195)	5.185	0.023*	0.641 (0.437–0.940)
Joint Sticking				
Gender^c	0.006 (0.309)	0.000	0.986	1.006 (0.549–1.842)
OH^a/OH^b	0.996 (0.607)/0.598 (0.373)	2.689/2.564	0.101/0.109	2.706 (0.823–8.895)/1.818(0.875/3.781)
Group^d	−0.386 (0.313)	1.523	0.217	0.680 (0.368–1.255)

Abbreviations: OH, Oral Parafunctional habits; CVD, Cardiovascular Disease; CI, Confidence Interval; OR, Odds ratio; SE, Standard Error; TMJ: Temporomandibular joint.
^{a}: having 1 to 3 habits (ref: no habit); ^{b}: having more than 3 habits (ref: no habit); ^{c}: (ref: male); ^{d}: (ref: without CVD).
$^*p < 0.05$, significant difference.

TABLE 4. Binary logistic regression summary for the signs of TMD and variables (girl/boy, with or without CVD and having oral parafunctional habits).

Variables	B (SE)	Wald	Sig	OR (95% CI)
Signs				
Muscular Tenderness				
Gender^c	−0.462 (0.176)	6.871	0.009*	0.630 (0.446–0.890)
OH^a/OH^b	0.350 (0.337)/0.248 (0.260)	1.079/0.915	0.299/0.339	1.419 (0.733–2.745)/1.282 (0.771– 2.132)
Group^d	−0.124 (0.176)	0.499	0.480	0.883 (0.626–1.247)
TMJ Pain				
Gender^c	−1.124 (1.160)	0.938	0.333	0.325 (0.033–3.158)
OH^a/OH^b	−16.792 (4158.64)/16.274 (4158.64)	0.000/0.000	0.997/0.997	0.000 (0.000)/0.000 (0.000)
Group^d	1.136 (1.160)	0.959	0.328	3.113 (0.321–30.229)
Joint Noise				
Gender^c	0.086 (0.181)	0.226	0.635	1.090 (0.764–1.554)
OH^a/OH^b	0.344 (0.336)/0.338 (0.249)	1.047/1.845	0.306/0.174	1.410 (0.730–2.725)/1.402 (0.861–2.282)
Group^d	−0.533 (0.182)	8.584	0.003*	0.587 (0.411–0.838)
Deviation				
Gender^c	−0.606 (0.177)	11.793	0.001*	0.545 (0.386–0.771)
OH^a/OH^b	0.223 (0.327)/0.268 (0.246)	0.465/1.182	0.495/0.277	1.250 (0.658–2.374)/1.307 (0.807–2.117)
Group^d	−0.454 (0.176)	6.627	0.010*	0.635 (0.450–0.897)
Subluxation				
Gender^c	0.182 (0.438)	0.174	0.677	1.200 (0.509–2.831)
OH^a/OH^b	1.553 (1.108)/0.439 (0.527)	1.966/0.694	0.161/0.405	4.724 (0.539–41.408)/1.552 (0.552–4.361)
Group^d	−0.396 (0.443)	0.801	0.371	0.673 (0.282–1.603)

Abbreviations: OH, Oral Parafunctional habits; CVD, Cardiovascular Disease; CI, Confidence Interval; OR, Odds ratio; SE, Standard Error; TMJ: Temporomandibular joint.
^{a}: having 1 to 3 habits (ref: no habit); ^{b}: having more than 3 habits (ref: no habit); ^{c}: (ref: male); ^{d}: (ref: without CVD).
$^*p < 0.05$, significant difference.

with CVD than without CVD. To the best of our knowledge, this is the first study performing such comparisons between CVD and non-CVD children. Therefore, it is difficult to compare the findings of the current study with others.

One of the main sources of non-dental pain in the orofacial region in children and adolescents is TMDs [20]. The prevalence of TMDs among children and adolescents ranges from 9.8% to 80.9% [13]. This remarkable variation in TMD prevalence among children and adolescents can be attributed to the utilization of different research methodologies, the selection of different clinical criteria for diagnosis, differences in population samples and changes in examination procedures [21]. In this study, we observed that the TMD prevalence rate was 87%, highest among children with CVD and permanent dentition, while it was only 80% among children without CVD. Additionally, the different prevalence rates for the signs and symptoms of TMD have been reported [15, 18]. Although TMJ clicking was reported as the most frequent sign in some previous studies [15, 23], others have reported muscle or TMJ tenderness to be the most frequent sign [22], which was similar to the results of the present study. In contrast, in the current study, "deviation" followed muscle or TMJ tenderness and clicking followed "deviation". This might be because deviation was not evaluated in some studies.

The onset age of TMDs in children and adolescents is still unknown [24]. In some studies, the prevalence of TMD was investigated and even included children as young as 3 years old [25], while in other studies, $\geq$10 years old children constituted the research group [26]. In a study by Howard *et al.* [27], of the 3428 patients enrolled from a healthcare organization who sought treatment for TMDs, 644 were reported to be 4–20 years of age and were undergoing treatment for TMDs. The lower limit of age in the present study was 6 years old because that was the youngest age of the children in primary school. However, it should also be noted that doubts might be inevitable about the credibility of self-reports by younger children. Pain assessment by self-report in the pediatric age range depends on the children's cognitive development, which often begins to emerge as early as 3 years of age and gradually develops to enable more accurate and reliable self-reporting of pain intensity by the age of 5 (on average) or older [28]. On the other hand, it was reported that experienced pediatric dentists can successfully obtain reliable information through communication, reading the patient's face and actions, and evaluation scales developed for children. In this study, the researchers, who were pain experts, took part in the evaluations and used the Face, Legs, Activity, Cry, Consolability (FLACC) and Wong-Baker Faces Pain Rating Scale when there was doubt about the child's understanding. These scales were proven to be valid for younger age groups [29, 30]. Additionally, reliable results were obtained with a friendly approach by reinforcing questions in the AAPD guideline with simpler questions for the children to understand (*i.e.*, "are you ok?", *etc.*) [16].

It was reported that children might not be aware of their TMD symptoms because the disease might be asymptomatic due to being at an earlier stage. Additionally, children may have fewer or more moderate TMD symptoms than adults [15]. Okeson *et al.* [19] found that many children were unaware of TMJ sounds that were later observed during clinical examinations. On the other hand, a study by Emodi-Perlman *et al.* [18] and Elbay *et al.* [15] reported a significant association between self-reported symptoms and clinically observable signs. In this present study, similar to the results of Okeson [19], in the clinical examination, pain-related signs (muscular tenderness) were observed at a higher rate than the pain rate according to the self-reported pain symptoms of children with both mixed and permanent dentition. However, surprisingly, in CVDG children, the rate of self-reported pain symptoms was lower than that in CG (mixed and permanent dentition). Moreover, children in CVDG with mixed dentition had fewer pain-related signs than healthy children during clinical examinations, possibly due to the following reasons. First, pain is subjective, learned through life experiences and influenced by biological, psychological and social factors [31]. It is highly likely that a child with CVD has had at least one surgical operation and has undergone numerous checkups and treatments. This process might also change a child's perception of pain and cause them to ignore low-level pain other than pain associated with illness. Second, several studies indicated that some CVDs were associated with decreased sensitivity to pain due to the pharmacologic effects of medications or blood pressure changes [32]. Although it has been reported in a few cases that severe joint pain might be a sign of a cardiovascular problem and related to some systemic diseases [33], there has been no research to investigate the relationship between TMDs and CVD. In this respect, the results of this study shed light on this issue, particularly in children and adolescents, suggesting the need for careful evaluation of TMDs in patients with CVD despite the absence of TMD pain complaints. In addition, patients presenting with severe TMD pain symptoms might be unaware of an underlying CVD, and the first contact of a patient with a possible heart disease might be a dentist.

The relationship between oral habits and TMDs seems to be controversial and unclear [34]. Oral habits are possible etiological factors in the development of TMDs at the young age groups [35]. In this present study, both children with and without CVD reported a similar incidence of parafunctional habits. Additionally, logistic regression analyses did not find any relationship between the presence of oral habits and clinical signs and symptoms, contrary to the association between muscular tenderness and bruxism alone in both groups. This result was not surprising since our research group was under 20 years of age. Many studies reported that symptoms and signs of TMDs increased in patients with parafunctional habits from younger to older age groups [36]. On the other hand, children with CVD showed "bruxism" and "fingernail biting" at a statistically higher rate than children without CVD. This finding supports studies that suggested a relationship between cardiovascular diseases and bruxism [37]. Among the children without CVD, "chewing gum" was the most reported habit related to muscular tenderness. Among healthy children, a higher rate of "chewing gum" was in agreement with the results of a previous study [38]. In contrast, among the children with CVD, this rate was $<$50% compared to that among healthy children with permanent dentition and $<$25% compared to that among healthy children with mixed dentition. The fact that this rate was much lower is not surprising considering the treatment and hospital processes for an individual with

CVD since chewing gum is a common function performed by children.

With regard to differences in sex, various studies have reported more frequent pain related to TMDs and other related signs/symptoms in females than in males [39], while no significant differences in sex were observed in other studies [15, 40]. This current study did not find a relationship between the symptoms of TMDs and sex according to logistic regression analysis. On the other hand, regression analysis showed that females were more prone to TMD tenderness and deviation during the clinical examination.

The settings for all the children were equal, although the healthy group was examined in the school nurse's office, while children with CVD were examined at a CVD clinic of a university hospital and could be considered a limitation in this study that might have led to reporting a lower pain score in the CVG in a hospital environment. However, the strength of our study was that only one examiner well-trained in DC/TMDs performed the clinical examinations of all children. Another limitation could be related to unclear or inaccurate self-reporting in younger children. However, this limitation was partly overcome by the fact that an experienced pediatric dentist carried out the research, the groups were homogeneous in terms of age range, and the analyses were performed separately among children aged <12 years and children aged ≥ 12 years.

5. Conclusions

The prevalence of TMDs and oral parafunctions did not vary significantly between the children with and without CVD. On the other hand, a significant relationship was found between the signs and symptoms of TMDs and the presence of CVD in children. As a result, parents and health practitioners should carefully assess the risks of CVD in children when diagnosing or taking measures for preventing TMDs in children. Additionally, more clinical studies are needed to examine the relationship between TMDs in adult and pediatric patients with heart diseases.

AUTHOR CONTRIBUTIONS

CU and AB—Data curation; ÜŞE and CU—Investigation; ÜŞE and ME—Methodology; ÜŞE and ME—Supervision; AB—Visualization; ME—Writing—original draft, review & editing; All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All procedures performed in the study were in accordance with the Ethics Committee of the Kocaeli University (KOU KAEK#17) and with the 1975 Declaration of Helsinki (as revised 2000) and its later amendments or comparable ethical standards. Informed consent was obtained from legal guardians.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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