

## Research article

# Is there any relationship between fixed orthodontic treatment and developmental indicators in children and adolescents? A prospective cohort study



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## ABSTRACT

**Background:** Fixed orthodontic treatment may cause discomfort four to six weeks after the initiation of the treatment as it may change the type and amount of food consumed by children. This temporary change may have a long-term effect on the growth status of such children. This study aimed to detect the longitudinal relationship between fixed orthodontic treatment and developmental indicators in children and adolescents.

**Methods:** The study population encompassed adolescents undergoing fixed orthodontic treatment as the exposure group (n = 30) and adolescents with no orthodontic treatment as the control group (n = 90). The patients' dental age, weight, height, body mass index (BMI), and wrist circumference were assessed at the baseline, as well as 1, 3, and 6 months after the orthodontic treatment. The significance level was set to be  $p = 0.05$ .

**Results:** One-hundred twenty participants were included in this study. In the two groups, all growth parameters revealed an increasing trend. In the exposure group, weight-related indices (i.e., weight, BMI, and wrist circumference) decreased in the first month and then increased during the next five months. All indices in the control group and height in the exposure group exhibited a continuous increase.

**Conclusion:** Fixed orthodontic treatment affects childhood growth indices. However, these effects are probably short-term, and the catchup growth mechanism can offset these effects and modify the changes in growth indices. A longer follow-up period is recommended to be considered by future researchers.

## 1. Introduction

Orthodontics deals specifically with the growth and development of the dentition, and in general, the growth and development of the whole body. The primary prevention of facial and dental deformities depends on the precise interpretation of the intrinsic skeletal patterns and the overall growth and development. In this regard, some factors such as heredity, function, environment, gender, nutrition, and metabolic factors significantly affect growth and development [1]. Physical growth and pubertal manifestations are valuable indicators for orthodontic diagnostic evaluations. Orthodontists frequently evaluate physical characteristics such as weight, height, skeletal maturity, and tooth development

subjected to biometric tests and compare them with standards using a large group of healthy cases to measure patients' growth and puberty [2].

Previous studies have indicated that the pain and discomfort of orthodontic treatment affect the patient's daily life and may change or limit his/her eating habits due to his/her inability to chew. Chewing ability usually subsides after 24 h, and it takes about two to four weeks for the ability to return to its baseline [3]. Pain and discomfort and the necessity of preventing orthodontic appliance breakage make patients change their diet, use softer foods, and reduce the volume of their consumed food [3]. Moreover, it is documented that orthodontic treatment induces physical, physiological, and emotional stress, thereby decreasing appetite. These dietary changes are often associated with the loss of body fat mass, weight loss, and body mass index (BMI) variations [4, 5].

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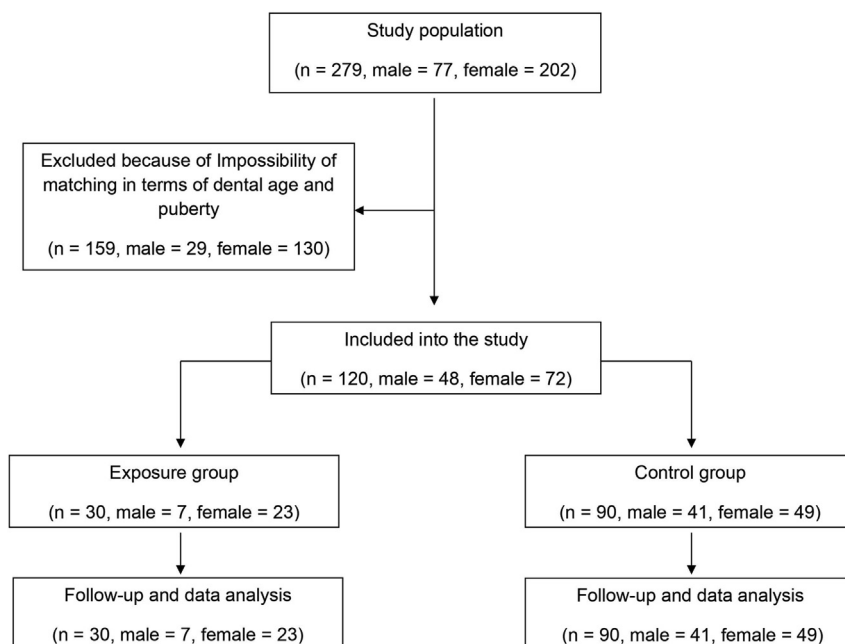


Figure 1. Flowchart of sample selection.

The relationship between weight with growth and puberty, has been addressed in several studies [6]. According to such studies, inadequate nutrition has long-term effects on children's development [6]. One of these studies reported that even minor weight losses in children with attention deficit hyperactivity disorder (ADHA) undergoing stimulant medication can lead to long-term variations in body composition [7]. Reiehr et al. concluded that a decreases in the BMI- Standard Deviation Score (SDS) was associated with the earlier gonadotropin-dependent onset of puberty in boys and the later onset of puberty in girls [8]. Swenne showed that weight gain is necessary for growth and must start before the growth ability is lost with age [9]. Growth and development in the dental structures can also be affected by nutrition. In this regard, a relationship is observed between the timing of baby tooth eruption and nutritional status [2]. The literature suggests that obesity can cause prognathic jaws [6]. Increased insulin and growth hormone levels, decreased bone mass, and testosterone levels are also associated with childhood obesity [6].

All previous studies have highlighted the effect of growth on orthodontic treatment. Considering the possible effects of orthodontic treatment on children's nutritional status during their critical period of growth, the present study detected the adverse effect of orthodontic treatment on growth.

## 2. Materials and methods

This prospective cohort study was performed from July 2019 to July 2020. The study population included children and adolescents aged 9–13 years (before the onset of growth spurts) dentition with and without fixed orthodontic treatment (edgewise appliance in both arches) as the case and control groups. The onset of growth spurts was determined by examining children and adolescents' height and weight curves and questions about their recent growth and the onset of the menstruation cycle in girls. The following exclusion criteria were considered in this study: a history of orthodontic treatment, periodontal disease, special diet prescribed by a nutritionist (due to reasons such as obesity, slimming, abnormal BMI, and specific diseases), craniofacial deformities, severe skeletal dysplasia, or systemic diseases. The study protocol was ethically approved by the Medical and Ethics Committee of Hamedan University of Medical Sciences (Code: IR.UMSHA.REC.1398.597). Informed consent was obtained from each patient or their representative authorities.

The exposure group was selected from patients referred to the Dental Faculties of the Hamedan and Semnan Universities of Medical Sciences. These patients were in late mixed and early permanent dentition and had class I malocclusion with no transverse or vertical discrepancy and required fixed orthodontic treatment for leveling and alignment. None of the patients needed permanent tooth extraction, functional appliances, or the force eruption of impacted teeth. All of these patients had mild to moderate crowding with no dentoalveolar protrusion. The control group was selected from children and adolescents in three schools in different regions of Hamedan and one school in Semnan. The schools were selected randomly, and the participants were matched by gender, nutrition status, initial physical status, chronological age, dental age, weight, height, BMI, and wrist circumference. According to the Index of Treatment Needs (IOTN), this group had an acceptable dental condition and did not need orthodontic treatment.

A questionnaire was used to collect data on demographic information (namely age, gender, specific illness, and place of residence), eating habits (consumption of ready-to-eat food, raw vegetables, fried foods, fruits, dairy, type of consumed oil), and daily activities (level of physical

Table 1. Baseline anthropometric parameters in the two groups.

Parameter		Exposure group (n = 30)	Control group (n = 90)	P value*
		n	N	
Sex	Female	17	53	0.732
	Male	13	37	
Nutrition	Proper nutrition	13	41	0.83
	Malnutrition	17	49	
Mobility	Normally active	19	63	0.76
	Inactive	11	27	
		Mean ± SD	Mean ± SD	P value**
Age, year		11.80 ± 0.59	11.84 ± 0.57	0.928
Dental Age, year		11.83 ± 0.40	11.62 ± 0.53	0.055
Weight, kg		45.18 ± 6.58	44.37 ± 6.56	0.059
Height, cm		152.19 ± 5.04	151.77 ± 5.97	0.812
Body mass index, kg/m <sup>2</sup>		19.49 ± 2.29	18.35 ± 2.35	0.124
Wrist circumference, cm		14.68 ± 1.18	14.73 ± 1.08	0.812

**Table 2.** Anthropometric parameters of exposure and control groups in 6-month follow-up.

Parameter		Baseline	1-month	3-month	6-month	P value (within group comparison)
		Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD	
Weight, kg	Exposure	45.18 $\pm$ 6.58	44.98 $\pm$ 6.40	46.20 $\pm$ 6.55	48.20 $\pm$ 7.41	0.001
	Control	42.37 $\pm$ 6.56	42.75 $\pm$ 6.60	43.47 $\pm$ 6.72	44.88 $\pm$ 7.21	0.001
	P value (between group)	0.059	0.126	0.045	0.042	Overall comparison 0.058
Height, cm	Exposure	152.19 $\pm$ 5.04	152.52 $\pm$ 5.05	153.50 $\pm$ 5.14	156.28 $\pm$ 5.42	0.001
	Control	151.77 $\pm$ 5.97	152.05 $\pm$ 5.97	152.69 $\pm$ 5.89	154.72 $\pm$ 4.44	0.001
	P value (between group)	0.256	0.812	0.339	0.769	Overall comparison 0.559
Body mass index, kg/m <sup>2</sup>	Exposure	19.49 $\pm$ 2.29	19.26 $\pm$ 2.20	19.61 $\pm$ 2.13	19.64 $\pm$ 2.14	0.001
	Control	18.35 $\pm$ 2.35	18.44 $\pm$ 2.34	18.59 $\pm$ 2.32	18.91 $\pm$ 2.34	0.001
	P value (between group)	0.124	0.094	0.030	0.044	Overall comparison 0.026
Circumference, cm	Exposure	14.68 $\pm$ 1.18	14.56 $\pm$ 1.11	14.89 $\pm$ 1.26	15.42 $\pm$ 1.36	0.001
	Control	14.73 $\pm$ 1.08	14.78 $\pm$ 1.11	14.96 $\pm$ 1.13	15.30 $\pm$ 1.18	0.001
	P value (between group)	0.812	0.339	0.769	0.637	Overall comparison 0.112

activities). The questionnaire was validated by Hosseini et al. in their study on high school students in Khorasan province, and its validity and reliability were tested and confirmed [10].

The sample size was calculated by PS Power and Sample size calculation software (Version 3, by William D. Dupont and Walton D. Plummer). Since this is a comparative study, and give that no similar article was found to determine the sample size, the minimum expected difference in the mean scores of the variables was considered a one-unit difference and a two-unit standard deviation in height. Furthermore, type 1 error and the power were 0.05 and %80, respectively. Sixty-five samples were assigned to each group.

After sample recruitment reached 30 persons in the exposure group and 90 persons in the control group, an interim analysis was performed due to the COVID-19 pandemic. The analysis showed a significant change in the mean score of variables in the two groups. Accordingly, the sample size was considered sufficient.

The participants were submitted a questionnaire in the first appointment, and the level of their daily activities and nutrition were examined. In the questionnaire, each answer was assigned a score; thus, the option with the minimum daily activity and with improper nutrition received the lowest score (zero), and the option with the maximum daily activity and proper nutrition was assigned the highest score. Finally, individuals with scores <12 and >12 in the nutrition questionnaire were considered malnourished and with proper nutrition, respectively. In the case of mobility, the participants with a mobility score <2 were considered inactive, and those with a mobility score >2 were considered normally active. To evaluate the growth status, weight and height, BMI, index, and wrists circumference were calculated using a single calibrated Beurer PS240 (Beurer, Germany) digital scale and a wall stadiometer (Accu-Hite wall stadiometer; Seca Corp, Hanover, MD). The dental age was determined by a panoramic X-ray examination and a clinical examination using the Demirjian method [11]. Since the control group needed no orthodontic treatment, cephalometric radiography was not performed due to ethical considerations. It was prescribed because panoramic radiography was used as part of their routine examination. On the recommendation of the American Dental Association, children with mixed dentition are prescribed panoramic and posterior bite-wing as a routine examination [12]. Samples were matched according to the findings of the initial assessments.

One, three, and six months after starting orthodontic treatment, the patient's weight, height, and wrist circumference were measured. Dental age was evaluated clinically at intervals of 1, 3, and 6 months. The appearance or absence of puberty was assessed at all intervals. The patients' growth curves in the two groups were plotted and compared with each other and with normal height and weight curves.

Statistical analysis was done by SPSS software version 23.0 (IBM, Armonk, New York). Mean, and standard deviation (SD) of quantitative

variables and frequency (percentage) of categorical variables were reported. Statistical tests such as t-test and chi-square test were used to compare two groups at baseline. The variation trend in the study parameters was assessed between and among groups, and the findings were compared using the Repeated Measure ANOVA test. In this study,  $p = 0.05$  was considered as the significance level.

### 3. Results

Initially, 279 patients (77 males and 202 females) were included. Because of the match between dental age and puberty, 159 participants were excluded. In other words, 120 patients (48 males and 72 females) were finally took part in the study and were followed-up for six months (Figure 1).

As shown in Table 1, no significant difference was observed between the exposure and control groups in baseline values of sex, nutrition state, activity, chronologic age, dental age, weight, BMI, height, and wrist circumference.

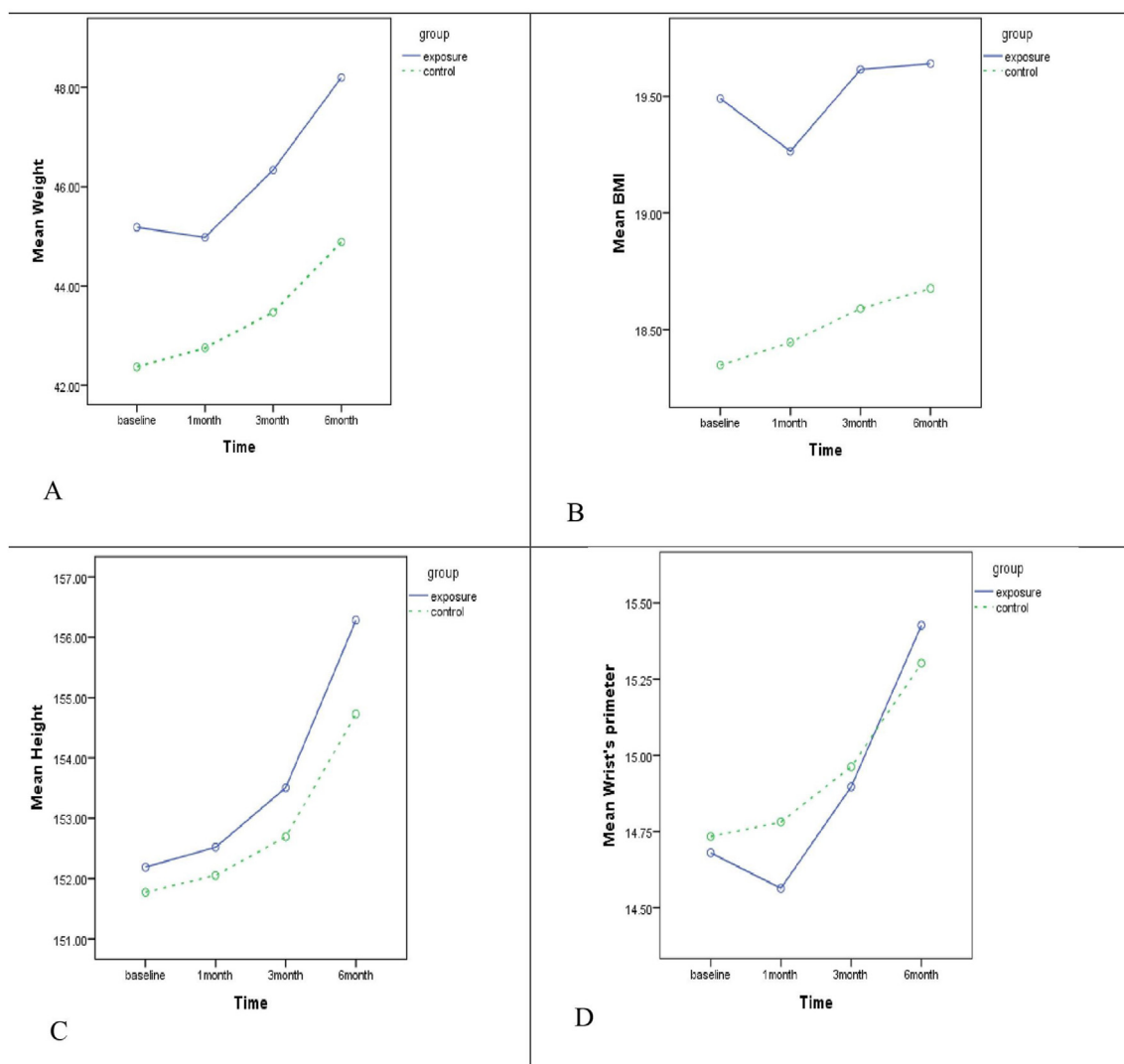
In the control group, all parameters increased continuously during the six months. In the exposure group, height was similar to the control group. However, weight, BMI, and wrist circumference decreased during the first month and increased afterward. After the first month, the increasing trend in the exposure group occurred with a greater slope (Table 2 and Figure 2). The individuals in the exposure group experienced higher mean values of weight and BMI during the third and sixth months of follow-up.

Assessing the changes in indices of male and female cases (Table 3) showed an increasing trend in both genders. BMI changes were different in boys and girls, with a higher slope in boys. However, the changes in other indicators between the two groups were not significant.

### 4. Discussion

Fixed orthodontic treatment can negatively affect the nutrition of patients. This temporary change in nutrition may not be important in adults. However, it may have a long-term effect on children and adolescents' growth status. The present study aimed to assess the growth indices of orthodontic and non-orthodontic patients longitudinally.

The present study revealed that all growth indices increased significantly over time compared to the baseline in both exposure and control groups, and this is a normal finding in children and adolescents. Rogol et al. reported that, from 4 years up to puberty, weight and height annually increase 2.5 kg (kg) and 5–6 cm (cm) on average, respectively. They also reported that boys experienced an average height increase of 10.3 cm per year during puberty (growth spurt), while girls showed a 9 cm height gain per year. Moreover, boys and girls experienced 9 and 8.3 kg per year of weight gain during this period, respectively [13]. Öztür



**Figure 2.** Line graph of changes in anthropometric parameters of exposure and control groups in 6-month follow-up. A. Mean weight; B. Mean BMI; C. Mean Height; D. Mean wrist's perimeter.

et al. reported that the average wrist circumference in boys increases from 13 cm at age 6–16.83 cm at age 17 years, and that the average wrist circumference in girls increases from 12.48 cm at age 6–15.58 cm at age 17 years [14]. Accordingly, the increasing trend in all anthropometric indices in both genders is normal and predictable.

Interestingly, wrist circumference, weight, and BMI values changed differently in the exposure and control groups. In the first month, these indices decreased in the exposure group, while they increased in the control group. Afterward, both groups showed an increasing trend. However, this occurred with a greater slope in the exposure group, especially after three to six months. This difference can be attributed to the pain aroused by orthodontic treatment, patient effort to avoid appliance damage, and discomfort. These can change the amount and type of food consumed during the first month of treatment. Patients mainly consumed soft food and neglected their nutritional value. Johal et al. reported that fat percentage and BMI decreased significantly during the first month of orthodontic treatment in children aged 11–14 years, and BMI in the control group increased simultaneously [15]. Sandeep et al. reported that weight, BMI, and the fat percentage significantly decreased one month after orthodontic treatment in adults aged 18–25 years, compared to the control group [3].

In the present study, weight and BMI gain were observed following weight and BMI loss in the first month of orthodontic treatment. This increase in weight and BMI occurred more severely in the exposure group

than in the control group, called catchup growth. This phenomenon is defined as “height velocity above the normal statistical limits for age and/or maturity during a defined period of time, following a transient period of growth inhibition.” Depending on the child's age, this phenomenon may lead to growth correction [16]. According to Sandeep et al., three months after orthodontic treatment, mean weight, BMI, and the fat percentage were similar between the exposed and control groups [3]. The decrease in the mentioned indicators during the first month after orthodontic treatment was partially compensated in the next two follow-up months; however, it did not reach the initial baseline level. According to the literature, weight gain is necessary for catchup growth and must start before the growth ability is lost with age [9]. Furthermore, studies have indicated that individuals with higher BMIs experience earlier puberty and increased growth indicators such as BMI [8, 17, 18]. Accordingly, a hypothesis is raised that although the changes are temporary, they can have a long-term effect on the growth in some patients. As a result, starting treatment in the last periods of growth may cause long-term growth disturbance.

In our study, the BMI variation patterns differed between boys and girls. In boys, BMI decreased in the first month and then increased up to six months. In girls, BMI decreased in the first month and increased during the first to the third months, and decreased once more during the third to the sixth months. This can be attributed to these individuals' different growth patterns. Tanner et al. indicated that height and weight

**Table 3.** Anthropometric parameters of both genders in 6-month follow-up.

Parameter	Exposure group (n = 30)		Control group (n = 90)	
	Male	Female	Male	Female
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
<b>Weight, kg</b>				
Baseline	46.74 ± 5.26	44.70 ± 6.96	43.00 ± 6.57	41.83 ± 6.56
1-month	46.48 ± 5.14	44.52 ± 6.78	43.37 ± 6.63	42.23 ± 6.60
3-month	47.84 ± 5.21	45.87 ± 6.95	44.08 ± 6.78	42.96 ± 6.70
6-month	50.14 ± 6.18	47.60 ± 7.77	45.59 ± 7.47	44.29 ± 7.00
P value (within group)	0.001	0.001	0.001	0.001
P value (between group)	P value (group) = 0.456 P value (sex) = 0.927			
<b>Height, cm</b>				
Baseline	151.47 ± 4.62	152.40 ± 5.24	150.10 ± 5.52	153.16 ± 6.02
1-month	151.81 ± 4.62	152.73 ± 5.25	150.34 ± 5.50	153.48 ± 6.02
3-month	152.47 ± 4.55	153.82 ± 5.36	150.98 ± 5.48	154.12 ± 5.90
6-month	154.90 ± 4.20	156.70 ± 5.76	152.61 ± 5.74	156.49 ± 6.52
P value (within group)	0.001	0.001	0.001	0.001
P value (between group)	P value (group) = 0.123 P value (sex) = 0.097			
<b>Body mass index, kg/m<sup>2</sup></b>				
Baseline	20.32 ± 1.54	19.23 ± 2.44	19.03 ± 2.32	17.77 ± 2.43
1-month	20.13 ± 1.49	19.00 ± 2.34	19.12 ± 2.31	17.87 ± 2.23
3-month	20.53 ± 1.55	19.33 ± 2.23	19.26 ± 2.31	18.02 ± 2.19
6-month	20.84 ± 1.67	19.27 ± 2.17	19.47 ± 2.32	18.00 ± 2.17
P value (within group)	0.001	0.036	0.001	0.001
P value (between group)	P value (group) = 0.046 P value (sex) = 0.003			
<b>Wrist circumference, cm</b>				
Baseline	15.25 ± 1.09	14.50 ± 1.17	14.97 ± 1.14	14.53 ± 1.00
1-month	15.14 ± 1.05	14.56 ± 1.09	15.02 ± 1.17	14.57 ± 1.02
3-month	15.41 ± 1.41	14.73 ± 1.20	15.19 ± 1.21	14.76 ± 1.03
6-month	15.90 ± 1.61	15.28 ± 1.29	15.53 ± 1.29	15.10 ± 1.05
P value (within group)	0.001	0.001	0.001	0.001
P value (between group)	P value (group) = 0.124 P value (sex) = 0.059			

gain occur simultaneously in adolescent boys; however, in girls, there is a six-month delay between weight gain and height increase, which would reduce BMI as well [13].

Some previous studies have examined the effect of orthodontic treatment on weight [3]; however, they did not include a control group. Comparing developmental indicators between peers is informative; thus, a cohort study and a control group would be of greater value. It should be noted that these samples would be continually assessed during one, two, and five years.

The main limitation of this study was caused by the COVID-19 pandemic, which affected sampling in the present study due to the occurrence of delay in dentistry treatments and suspension of schools. Accordingly, we conducted an interim analysis and terminated sample recruiting. The other limitation of this study was self-reporting of the nutrition state.

## 5. Conclusion

Fixed orthodontic treatment may affect growth indices in patients receiving the treatment. One of the effective factors in creating these changes is the pain and discomfort experienced during the first 4–6 weeks of treatment, which causes a change in the type and amount of the consumed food. Any disturbance in energy and protein intake may inhibit growth; however, these effects may be short-term, and the catchup growth mechanism can compensate for these effects in most patients. Continuing this study until the end of the developmental period of children and adolescents is recommended to obtain definitive results.

## Declarations

### Author contribution statement

Sepide Soheilifar and Navid Naghdi: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

Hamed Akbari: Performed the experiments; Wrote the paper.

Homa Farhadifard: Performed the experiments; Contributed reagents, materials, analysis tools or data.

Sanaz Soheilifar: Conceived and designed the experiments; Wrote the paper.

Sara Soheilifar: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Maryam Farhadin: Analyzed and interpreted the data.

Maryam Heydarpour: Analyzed and interpreted the data; Wrote the paper.

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### Data availability statement

Data will be made available on request.

*Declaration of interest's statement*

The authors declare no conflict of interest.

*Additional information*

No additional information is available for this paper.

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