Effect of Treatment with Twin-Block Appliances on Body Posture in Class II Malocclusion Subjects: A Prospective Clinical Study

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Background:
There is strong evidence that malocclusion and body posture are interdependent. The relationship between improvement of nasopharyngeal airway, correction of malocclusion by orthodontic treatment or orthognathic surgery, and changes in body posture were evaluated in several studies. The purpose of the present study was to analyze the effect of the orthodontic treatment with Twin-block appliance on body posture.

Material/Methods:
The study group consisted of 23 children (mean age 12.45 (1.06) years). They were orthopedically (back shape analysis) and orthodontically (cephalometric radiograph analysis) examined before the treatment with Twin-block appliance and 10-14 months after the beginning of treatment.

Results:
Treatment with Twin-block appliance caused mandibular protrusion as SNB increased by 0.91°, distance Ar-B increased by 4.9 mm, ANB decreased by 0.15°; and increase of face height. Oropharynx airway increased by 1.54 mm and deep pharynx airway by 1.08 mm. The decrease in kyphotic, lordotic, craniocervical angles, upper thoracic, pelvic, and trunk inclinations was found to be statistically significant. When comparing orthopedic measurements between study and control groups, no differences were detected. The control group also showed reduction of all measured angles. Although the decrease of kyphotic angle, upper thoracic inclination, trunk inclination, and craniocervical angle were more pronounced in the study group, the differences were not significant.

Conclusions:
Based on these results, the body posture changes during treatment with Twin-block appliance were an expression of the physiological growth, not a response to improvement in occlusion.

MeSH Keywords:
Airway Management • Cephalometry • Orthodontic Appliance Design

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Background

Pathological orthopedic findings are highly prevalent among individuals with orthodontic anomalies [1]. The relationship between occlusal relationship and body posture has been a subject of heated discussions for over 40 years. Recently, there has been increased interest in the relationship between occlusion and body posture. Some authors found strong evidence for an association between malocclusion and posture, especially with regard to the head and neck [2–4].

Several studies revealed that children who have Class II malocclusion tend to keep their head in the upright and forward position [2,3], and that there is a significant correlation between malocclusion and cervical lordosis [4,5].

It is also evident that structural orthopedic diseases are associated with occlusal morphology [6,7]. However, there are still controversial results from available studies about the correlation between poor body posture and occlusion. In a review, Michelotti et al. concluded that the correlation between occlusion and posture appears to be limited to the cranio-cervical portion of the vertebral column and tends to disappear when descending in the caudal direction [8].

Lippold et al. proved that vertical and sagittal mandibular position correlate with cervical flexion, pelvic angles, and pelvic torsion; however, the position of the maxilla does not correlate with back curvatures [9,10]. However, other studies did not show any significant correlation between malocclusion and orthopedic parameters [11–13].

If occlusion and head/body posture are interdependent, it is reasonable to presume that the change of occlusion might have an effect on a body posture. Recent studies demonstrated an immediate effect of different jaw relations on body posture. Cuccia stated that the plantar surface of a foot was differently affected by the dental occlusion, and that pathological condition of the stomatognathic system could influence the posture [14]. In contrast, Perinetti et al., in a posturography study, did not find a detectable correlation between the dental occlusion and body posture [15]. Marini et al. showed that the experimental occlusal interference did not significantly influence the body posture [16].

The relationship between improvement of nasopharyngeal airway, correction of malocclusion by orthodontic treatment or orthognathic surgery, and changes in body posture were evaluated in several studies [13,17–22]. However, the results from available studies are very controversial. Furthermore, only a few studies have evaluated changes in cervical posture during orthodontic treatment with functional appliances [19,21]. Aggarwal et al. established a significant increase in postural and maximal clenching EMG activity in masseter and a numeric but not significant increase in anterior temporalis activity during the 6-month period of treatment with the Twin-block; they stated that functional appliances are shown to modify the neuromuscular environment of the dentition and associated bones. The effect of functional treatment on body posture has not been evaluated yet.

Therefore, the aim of the present study was to analyze the effect of orthodontic treatment with Twin-block appliance on body posture.

Material and Methods

The study sample was obtained from consecutive patients at the Department of Orthodontics who agreed to participate in the study. A full explanation of the study aims and procedures was provided to the parents of each patient and signed consent was obtained. The study was approved by the Ethics Committee (No. BEC-LSMU(R)-29).

The initial study sample comprised 42 subjects who began their treatment with Twin-block appliance in the Department of Orthodontics.

The criteria for patient selection were:
1. White ethnicity, age 10–15 years.
2. Skeletal Class II malocclusion (no less than ½ cusp Class II molar relationship, retrusive lower jaw, ANB >4°).
3. Late mixed or early permanent dentition.
4. No history of maxillofacial trauma or surgery, syndromes, clefts, or orthodontic treatment.
5. No previous treatment of orthopedic disorders.
6. No previous injury to the pelvis, spine, or long bones.

However, 19 subjects were excluded from the final study sample: discontinued orthodontic treatment or showed a lack of compliance in wearing the appliance (did not wear the appliance, did not arrive to control appointments); therefore, improvement of the occlusion was not observed. Eventually, the final study sample consisted of 23 children aged 10–15 years (mean age 12.45±1.06 years, 13 boys and 10 girls), who were orthopedically and orthodontically examined before treatment and 10–14 months after the beginning of treatment, when Class I molar relationship was achieved. Non-cooperating patients were re-invited to a repeated consultation 1 year after the initial examination. Fourteen of 19 patients responded to the re-invitation. These 14 patients were chosen as controls and were repeatedly orthopedically examined. All patients passed an examination performed by the same clinical team in a blinded manner.
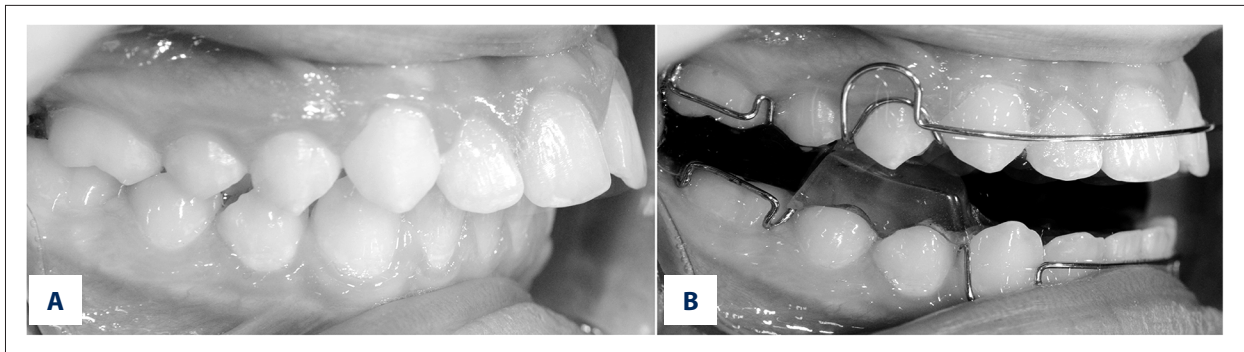
Figure 1. The Twin-block appliance: (**A**) lateral occlusion at the beginning of treatment; (**B**) patient with Twin-block appliance.

Treatment protocol

A modification of the Twin-block appliance, originally developed by W.J. Clark, was used in this study [24]. The appliance was composed of maxillary and mandibular removable appliances, retained with Adams clasps on the maxillary and mandibular first permanent molars and c clasps on the maxillary first premolars. The maxillary labial bow, extended from first premolar to first premolar tooth, and mandibular labial bow, extended from canine to canine, were also used to retain the appliance and control incisors proclination. For those patients whose pre-treatment overjet did exceed 6 mm, the appliances were constructed from bite registrations taken with the incisors in an end-to-end position. In instances when the pre-treatment overjet exceeded 6 mm, the bite registration was obtained with the mandible initially postured forward up to 6 mm, with the appliance reactivation after a few months to the end-to-end position (Figure 1). The patients were instructed to wear the Twin-block appliance 16-18 hours a day and to turn the maxillary expansion screw 1 turn per week in order to correct transversal dental arch width discrepancy. Each child was reviewed at intervals of 8 weeks over the active treatment time.

Cephalometric analysis

A standardized lateral cephalometric radiograph was taken for each patient (Kodak 8000C; enlargement factor 1.15; exposure: 12 mAs, 76–80 kV) and analyzed using Dolphin software (version 10.5) in order to evaluate:

- SNA – angle represents the anterior-posterior position of the maxilla in relation to the cranial base. Mean value 82±2°.
- SNB – angle represents the anterior-posterior position of the mandible in relation to the cranial base. Mean value 80±2°.
- ANB – angle indicates the magnitude of sagittal skeletal jaw discrepancy. Mean value 2±2°.
- AFH (N-Me) – anterior face height. Mean value 128.5±5 mm.
- LFH (ANS-Me) – lower face height. Mean value 65±4.5 mm.
- SN to MP (Go-Gn) – angle represents the inclination of the mandibular plane in relation to the anterior base of the cranium. Mean value 32±5°.

- SN to PP (ANS-PNS) – angle indicates the degree of inclination of the maxillary plane in relation to the anterior base of the cranium. Mean value 7.3±3.5°.
- OKL-SN (occlusal plane to SN) – angle determines the rotation of occlusal plane in relation to the anterior base of the cranium. Mean value 14.5±2°.
- INCIS (Max. to Mand. Incisor) – angle indicates the position of the upper incisor relative to the lower incisor. Mean value 130±6°.
- U1-PP (Max. Incisor to PP) – angle represents the relationship of the upper incisors to the palatal plane. Mean value 110±5°.
- L1-MP (Mand. Incisor to Go-Gn) – angle indicates the axial inclination between the mandibular incisor and the inferior border of the mandible. Mean value 90±5°.
- Ar-A (mm) – total length of the maxillary base.
- Ar-B (mm) – total length of the mandibular base.
- Pharyngeal width measurement was based on Arnett/Gunson FAB analysis (Dolphin Imaging 10.5 software). All measurements were made perpendicular to the true vertical line.
– Nasopharynx airway Aa-Ap (A anterior (Aa) – nasopharynx anterior wall passing through skeletal point A; A posterior (Ap) – nasopharynx posterior wall passing through skeletal point A).
– Oropharynx airway S1a-S1p (S1 anterior (S1a) – oropharynx anterior wall passing through the tip of upper incisor; S1 posterior (S1p) – Oropharynx posterior wall passing through the tip of upper incisor).
– Hypopharynx airway Ba-Bp (B anterior (Ba) – hypopharynx anterior wall passing through skeletal B point; B posterior (Bp) – hypopharynx posterior wall passing through skeletal B point).
– Deep pharynx airway Pga-Pgp (Pg anterior (Pga) – deep pharynx anterior wall passing through skeletal Pog point; Pg posterior (Pgp) – deep pharynx posterior wall passing through skeletal Pog point).

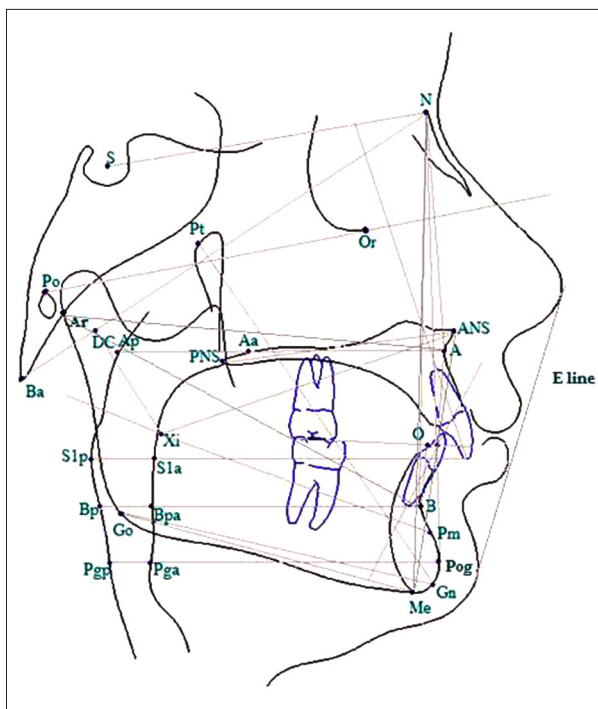Cephalometric landmarks, used for measurement, are shown in Figure 2.

Figure 2. Cephalometric landmarks.

The error margins for the cephalometric analysis were determined by repeatedly measuring the 6 variables on 10 randomly selected radiographs at 2-week intervals. Measurements were made by the same operator. Error analysis was done by using a paired t-test and Dahlberg formula.

Orthopedic examination

The orthopedic examination consisted of the photographic back shape analysis. The patients were photographed from the side. Orthopedic examination was performed by an expert investigator in a quiet consulting room. The camera was placed on a tripod and calibrated with a builder's level. The distance between the camera and the patient was standardized. Patients were asked to stand beside a wall in an upright position, looking straight ahead, barefoot, shoulders relaxed, without moving (relaxed standing posture). A vertical line on the wall was selected as a guiding dimension (plumb line) when performing measurements on pictures taken.

The measurements were obtained from a picture (Figure 3). Every picture was opened using Microsoft Office Picture Manager. The Screen Protractor (version 4.0) program was used for measuring angles.

Photographic back shape analysis was performed using criteria proposed by Lippold et al. [11]. Evaluated measurements:
• The kyphotic angle – the angle between the tangent lines in CTP and TLP.
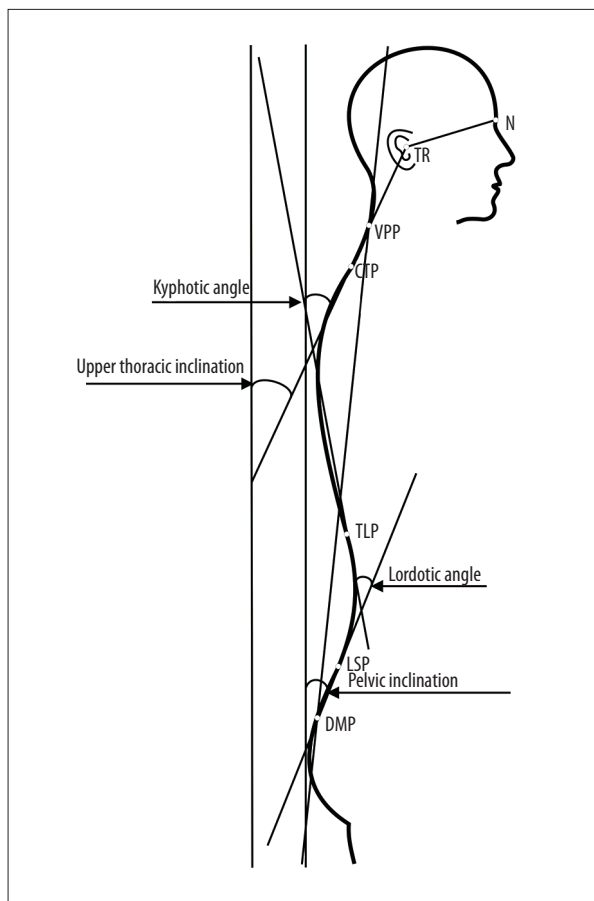
Figure 3. Points and angles used in orthopedic analysis. CTP – cervico-thoracic inflection point; TLP – thoraco-lumbar inflection point; LSP – lumbo-sacral inflection point; VPP – point of the most prominent spinous process of seventh cervical vertebra; DMP – geometric midpoint between lumbar dimples; N – soft tissue Nasion; Tr – auricular tragus.

• Tthe lordotic angle – the angle between the tangent lines in TLP and LSP.
• The upper thoracic inclination- the angle between the plumb line and the CTP tangent.
• The pelvic inclination – the angle between the plumb line and the LSP tangent.
• The trunk inclination – the angle between the plumb line and the line drawn through VPP and DMP.
• Craniocervical angle – the angle between lines, drawn through points N, Tr, and VPP [25].

To assess the method error of orthopedic investigation, 10 patients were repeatedly photographed and examined. Measurements were made by the same operator. Error analysis was done by using a paired t-test and Dahlberg formula.

Table 1. The power analysis to determine the sample size.

Variables	Mean$_1$ (SD$_1$)	Mean$_2$ (SD$_2$)	r	Power
ANB	4.66 (1.81)	3.51 (1.96)	0.9	1.0
SNB	77.3 (2.9)	78.2 (3.2)	0.9	0.84

SD – std. deviation; r – correlation coefficient.

Statistical analysis

All statistical analyses were performed using statistical software package SPSS 20.0 for Windows. To compare the mean values, the independent and paired t-tests were used, if the distribution of data was normal. In case of a non-normal data, the Mann-Whitney U test was used. Finally, a correlation analysis, using the Spearman correlation coefficient, was computed in order to evaluate any existence of significant interdependence between the change in orthodontic parameters and clinical orthopedic measurements. A p-value of <0.05 was considered statistically significant.

Sample size analysis

The power analysis was used to determine the sample size. Variables ANB and SNB, before and after the treatment, and type I error α=0.05 were chosen. The results showed that sample size composed of 23 patients is sufficient because the statistical power is >0.8, indicating type II error β<0.2 and a statistically significant difference (Table 1).

Results

Error analysis was done through a paired t-test, which evaluated systemic error, and was complemented by the Dahlberg formula, which evaluated random error. The paired t-test between the first and second cephalograms digitalization times showed no significant differences. The Dahlberg formula showed random errors mean value D=0.167. There were no significant differences on the paired t-test between the first and repeated orthopedic patient evaluation measurements. The Dahlberg formula showed random errors mean value D=0.412.

Changes of cephalometric parameters during the treatment with Twin-block appliance are shown in Table 2. Statistically significant reduction of OJ and OB was observed. Skeletal changes which conditioned this improvement in occlusion were: an increase of the SNB angle and distance Ar-B, decrease of ANB angle, and increase of AFH and LFH values (p<0.05). There was also a significant increase in oropharynx and deep pharynx airway widths.

Changes of the orthopedic measurements during the treatment with Twin-block appliance are shown in Table 3. Statistically significant reduction of all measured angles was observed during the treatment period.

Based on the ANB angle change median, 2 groups were separated: ANB group 1 when the reduction of ANB angle was <1.2° (n=12, 52.2%), and ANB group 2 when the reduction of ANB angle was >1.2° (n=11, 47.8%).

When evaluating orthopedic changes between ANB groups, a statistically significant difference was established only for the "Kyphotic angle" variable. In cases where correction of the ANB angle was less than 1.2°, reduction of the kyphotic angle was 2.71° (5.18); however, when correction of ANB angle was more than 1.2°, reduction of kyphotic angle was 9.22° (6.49) (p=0.009). No other significant correlations between the change in orthodontic parameters and clinical orthopedic measurements were found.

To discern which orthopedic changes are related to treatment with Twin-block appliance and which to normal patient growth, 14 patients who showed poor cooperation during treatment were chosen as a control group, mean age 12.73 years (0.91), who were repeatedly orthopedically examined. There were no statistically significant differences in mean age, pre-treatment orthopedic, or cephalometric measurements between the study group and control group (Table 4).

When evaluating orthopedic changes during the treatment period, no significant differences between the study and control groups were observed (Table 5).

Discussion

The main objectives of the treatment with Twin-block appliance are the correction of Class II malocclusion and reduction of overjet and overbite. Management of distal occlusion with functional appliances can lead to improvement in lip competency and orofacial function through muscle adaptation along with dental and skeletal changes. As a result, changes in the relationship between the jaws might induce body posture adaptations. The present study was conducted to determine if the correction of the Class II malocclusion with Twin-block appliance could positively affect body posture.

Table 2. Changes of cephalometric measurements during treatment with Twin-block appliance (n=23).

Variable	Before treatment T_1 Mean (SD)		After treatment T_2 Mean (SD)		Difference T_1–T_2 Mean (SD)		P value
OB (mm)	4.39	(1.41)	2.59	(1.61)	−1.80	(1.23)	**<0.001***
OJ (mm)	5.90	(3.00)	3.37	(1.97)	−2.54	(2.33)	**<0.001***
SNA (°)	81.96	(2.67)	81.71	(2.95)	−0.25	(1.20)	0.325
SNB (°)	77.30	(2.86)	78.21	(3.18)	0.91	(1.14)	**0.001***
ANB (°)	4.66	(1,82)	3.51	(1.96)	−0.15	(0.90)	**<0.001***
AFH: N-Me (mm)	105.65	(4.76)	110.38	(5.26)	4.73	(2.40)	**<0.001***
LFH: ANS-Me (mm)	58.22	(4.10)	61.29	(4.89)	3.07	(1.92)	**<0.001***
SN-MP (°)	30.22	(6.24)	30.16	(6.89)	−0.07	(1.92)	0.872
SN-PP (°)	6.52	(2.84)	6.59	(3.03)	0.07	(1.94)	0.857
OKL-SN (°)	13.54	(4.71)	14.35	(5.32)	0.80	(3.09)	0.224
INCIS (°)	133.81	(9.89)	135.34	(9.85)	1.53	(9.18)	0.434
U1-PP (°)	108.55	(10.11)	106.72	(8.85)	−1.83	(7.78)	0.271
L1-MP (°)	93.95	(6.30)	94.38	(7.10)	0.43	(3.96)	0.608
Ar-A (mm)	82.64	(4.38)	84.48	(4.32)	1.85	(2.59)	**0.002***
Ar-B (mm)	87.21	(4.23)	92.11	(4.37)	4.90	(2.99)	**<0.001***
Nasopharynx airway (mm)	14.32	(2.36)	14.96	(3.03)	0.64	(3.29)	0.361
Oropharynx airway (mm)	9.30	(2.69)	10.84	(3.65)	1.54	(2.48)	**0.007***
Hypopharynx airway (mm)	8.85	(3.47)	9.27	(3.14)	0.42	(2.76)	0.476
Deep pharynx airway (mm)	8.08	93.23)	9.16	(3.37)	1.08	(2.23)	**0.029***

SD – std. deviation; * the difference is statistically significant.

Table 3. Changes of orthopedic measurements during treatment with Twin-block appliance (study group, n=23).

Variable	Before treatment T_1 Mean (SD)		After treatment T_2 Mean (SD)		Difference T_1–T_2 Mean (SD)		P value
Kyphotic angle (°)	35.20	(8.70)	28.83	(6.65)	−6.37	(6.73)	**<0.001***
Lordotic angle (°)	32.24	(10.06)	26.35	(6.66)	−5.90	(8.28)	**0.002***
Upper thoracic inclination (°)	15.02	(4.69)	12.84	(3.37)	−2.17	(3.37)	**0.005***
Pelvic inclination (°)	18.31	(4.05)	15.57	(3.38)	−2.74	(3.39)	**0.001***
Trunk inclination (°)	7.69	(3.43)	6.63	(1.91)	−1.06	(1.91)	**0.014***
Craniocervical angle (°)	132.34	(7.15)	124.22	(6.61)	−8.50	(6.85)	**<0.001***

SD – std. deviation; * the difference is statistically significant.

The period of appliance wearing was standardized to 10–14 months based on the results of studies evaluating the treatment effects produced by the Twin-block appliance. This time period is sufficient to ensure skeletal change and reduce relapse [26,27]. Potential advantages of functional appliances are: enlargement of transverse width of dental arches to relieve crowding, diminishing adverse fixed appliance problems such as gingival proliferation and decalcification, reducing

Table 4. Comparison of cephalometric and orthopedic measurements before treatment between study and control groups.

Variable	Study group (n=23) Mean (SD)		Control group (n=14) Mean (SD)		P value
Cephalometric measurements					
OB (mm)	4.39	(1.41)	5.10	(1.34)	0.15
OJ (mm)	5.90	(3.00)	7.43	(2.80)	0.15
SNA (°)	81.96	(2.67)	80.48	(3.40)	0.12
SNB (°)	77.30	(2.86)	76.20	(4.10)	0.29
ANB (°)	4.66	(1.82)	4.30	(2.00)	0.58
AFH: N-Me (mm)	105.65	(4.76)	105.53	(5.78)	0.95
LFH: ANS-Me (mm)	58.22	(4.10)	58.75	(5.84)	0.90
SN-MP (°)	30.22	(6.24)	29.88	(7.88)	0.88
SN-PP (°)	6.52	(2.84)	5.27	(1.24)	0.22
OKL-SN (°)	13.54	(4.71)	11.07	(8.04)	0.33
INCIS (°)	133.81	(9.89)	129.50	(10.30)	0.22
U1-PP (°)	108.55	(10.11)	111.48	(8.42)	0.35
L1-MP (°)	93.95	(6.30)	93.92	(5.08)	0.99
Ar-A (mm)	82.64	(4.38)	83.00	(6.23)	0.82
Ar-B (mm)	87.21	(4.23)	87.00	(5.51)	0.89
Nasopharynx airway (mm)	14.32	(2.36)	15.65	(3.30)	0.53
Oropharynx airway (mm)	9.30	(2.69)	11.30	(2.92)	0.30
Hypopharynx airway (mm)	8.85	(3.47)	11.20	(3.93)	0.50
Deep pharynx airway (mm)	8.08	93.23)	8.38	(3.35)	0.80
Orthopedic measurements					
Kyphotic angle (°)	35.20	(8.70)	32.51	(8.18)	0.48
Lordotic angle (°)	32.24	(10.06)	36.00	(11.08)	0.16
Upper thoracic inclination (°)	15.02	(4.69)	13.44	(3.17)	0.40
Pelvic inclination (°)	18.31	(4.05)	20.50	(4.30)	0.18
Trunk inclination (°)	7.69	(3.43)	7.01	(2.00)	0.48
Craniocervical angle (°)	132.34	(7.15)	133.00	(10.86)	0.45

treatment time with fixed appliances, and reducing dysfunctional habits. It is also established that the prevalence of root resorption is significantly lower during treatment with functional appliances when compared to fixed appliances [28,29]. Significant associations exist only among root resorption and the magnitude of overjet reduction. There are potential disadvantages of the treatment with Twin-block appliance, such as the proclination of the lower incisors, development of posterior open bites, and poor patient cooperation. It is important

to note that in the present study cooperation of patients was insufficient: 45% of the patients discontinued orthodontic treatment or showed lack of compliance, which is a much larger dropout rate than in other studies [27]. This large dropout rate also determined a small final sample size; however, according to power analysis, the sample size was still sufficient. The reason for such poor patient cooperation could be related to the payment system, in which care is provided at no direct cost to the patient. Another reason is that the Twin-block

Table 5. Comparison of orthopedic parameters in treatment and control groups.

Variable	Study group (n=23) Difference T_1–T_2 Mean (SD)		Control group (n=14) Difference T_1–T_2 Mean (SD)		P value
Kyphotic angle (°)	−6.37	(6.73)	−5.51	(5.40)	0.91
Lordotic angle (°)	−5.90	(8.28)	−8.56	(11.32)	0.14
Upper thoracic inclination (°)	−2.17	(3.37)	−0.89	(1.36)	0.27
Pelvic inclination (°)	−2.74	(3.39)	−2.50	(2.26)	0.99
Trunk inclination (°)	−1.06	(1.91)	−0.62	(0.82)	0.53
Craniocervical angle (°)	−8.50	(6.85)	−7.00	(7.37)	0.74

appliance is quite bulky and therefore could negatively impact patient motivation to cooperate.

The short-term effects of treatment performed with Twin-block appliance evaluated in the present study were similar to those of other studies [30,31]. Briefly, the main skeletal effects were: advancement of mandibular position (increase of SNB angle and Ar-B distance), consequently correction of sagittal skeletal jaw discrepancy (decrease of ANB angle), and increase of face height (increase of AFH and LFH values). A statistically significant dentoalveolar effect on incisors was not observed, but there was a significant increase in oropharynx and deep pharynx airway widths.

Photometry (measurements on photogrphs) to evaluate body posture is a good clinical alternative to other methods such as the use of radiographs because it is noninvasive, inexpensive, and more objective than visual assessment [25]. When evaluating changes in body posture, a statistically significant reduction of all measured angles was observed during the treatment period. This shows the straightening of the patients' back profile. The most notable effect was seen on kyphotic and craniocervical angles, which are closely related to the posture of the head. We divided the patients into 2 groups based on the amount of the ANB angle improvement. Analysis of orthopedic measurements between groups showed that only differences in kyphotic angle were statistically significant: a greater correction of the ANB angle resulted in a greater reduction of kyphotic angle. No other differences were detected. Based on these results, it is possible that changes in occlusion can cause postural changes only in the upper portion of the vertebral column.

Numerous studies have attempted to show causal relationships between body posture, upper-body strength, and occlusion, especially its vertical dimension (which in the present study is a part of Twin- block appliance treatment) [14–16,32]. We did not find any studies evaluating the effect of functional treatment on body posture. A few studies show that orthodontic

treatment with functional appliances can cause changes in cervical posture. Tecco et al., in a controlled study, compared postural changes in 20 children treated with the Frankel Functional Regulator appliance. The cervical lordosis angle increased in the study group at the end of treatment, probably due to a significant backward inclination of the upper segment of the cervical column, but there was no significant change in the lower segment of the cervical column inclination [19]. Concordant with the present study results, Ohnmeis et al., in a retrospective cephalometric study, concluded that the cervical spine was straighter after orthodontic treatment with functional appliances, but they suggested that such straightening could be a result of physiological growth [21].

Changes in body posture could also be related to increase in the oropharynx and deep pharynx airway width during treatment with functional appliances. Airways obstruction usually leads to postural changes and head extension [33]. There is a consensus that anterior head tilting, in order to facilitate oral breathing and to physiologically compensate for nasal airway inadequacy, is the main change. Some studies confirmed that improvement in nasopharyngeal airway adequacy by tonsillectomy, adenoidectomy, rapid maxillary expansion, and cortisone therapy reduced craniocervical angulation [20,22]. Tecco et al. suggests that improvement of nasopharyngeal airway adequacy associated with rapid maxillary expansion was mildly associated with a decreased craniocervical angle, an increased cervical lordosis angle, and an anterior head tipping [20]. McGuiness and McDonald stated that rapid maxillary expansion has no significant effect on head posture in the short term. However, 1 year after expansion, a statistically significant reduction in head elevation was noticed [22].

The use of lateral cephalograms for the airway analysis is an established tool, in spite of the fact that the method has limitations, particularly inadequate, only 2-dimensional, description of 3-dimensional structures. However, according to Vizzotto et al., evaluating the accuracy of airway measurements from

lateral cephalograms and comparing them to the CBCT results showed reliability of cephalometric analysis in upper airway evaluation [34]. The results of the present study showed that oropharynx and deep pharynx airway increase is statistically significant (by 1.54 mm and 1.08 mm, respectively). The positive effect of functional appliance therapy on the pharyngeal airway passage dimension was found in other studies [35]. Jena et al. and Ghodke et al. also noted that oropharynx and hypopharynx depth increased significantly, but nasopharynx dimension did not change during treatment with the Twin-block appliance [36,37]. They concluded that anterior mandible displacement with the Twin-block appliance changes hyoid bone position, consequently causes forward tongue relocation, which leads to improved airway dimension.

The present study group consisted of growing children (mean age 12.45 (1.06) years). A healthy child at around 7 years of age assumes a normal-shaped spine with physiological curves. Then the spine grows unevenly, a period of accelerated growth occurs at between 10.5 and 15.5 years. Acceleration of the craniofacial growth also occurs at a similar age. Perillo et al. evaluated cephalograms of healthy children between 8 to 12 years old and found that the changes in angular and linear parameters occurred mostly between the ages of 10 and 12 years. The SNB values increased and ANB and SN-GoMe values decreased [38]. The findings of Baccetti et al. show that optimal timing for Twin-block therapy is during or slightly after the onset of the pubertal peak in growth velocity [39]. When compared with early treatment, late Twin-block treatment produced more favorable effects, greater skeletal contribution to molar correction, larger increments in total mandibular length and in ramus height, and more posterior direction of condylar growth, leading to enhanced mandibular lengthening and to reduced forward displacement of the condyle in favor of effective skeletal changes.

When evaluating treatment results on growing patients, it is important to determine if observed body posture changes were related to the improvement of occlusion, lip competence and (perhaps) opening of the airway, or whether these changes were just an expression of the physiological growth. The shortcoming of the present study is the absence of a well-formed control group because of ethical reasons. Therefore, we chose a control group from patients who showed lack of compliance during treatment and whose occlusion correction was not observed. After evaluating the body posture changes of the treatment group, the straightening of the back profile was observed. This could be an important therapeutic aspect. However, comparing orthopedic measurements of the treatment group with measurements of controls, no differences between groups were detected. The control group also showed reduction of all measured angles. Although the decrease of kyphotic angle, upper thoracic inclination, trunk inclination, and craniocervical angle were more pronounced in the study group, the differences were not significant. This suggests that observed body posture changes, at least during the 1-year period studied, are not related to orthodontic treatment and improvement in occlusion, but is an expression of the physiological growth.

Conclusions

Analysis of the body posture changes showed the straightening of the back profile and the statistically significant reduction of all measurements during treatment with the Twin-block appliance. However, based on these results, it must be assumed that the body posture changes were an expression of the physiological growth rather than a response to improved occlusion.

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