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Evaluation of Body Posture during Class II Functional Treatment with Fränkel II: A Longitudinal Study

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Abstract: The aim of the current study was to evaluate the changes in body posture in pubertal subjects characterized by Skeletal Class II with mandibular retrusion pre- and post-Fränkel II (FR-2). The treatment of Skeletal Class II with functional therapy has been already correlated with changes in cervical posture, but no previous studies investigated the possible relation with the posture of the whole body. This is an observational longitudinal study conducted on 17 Caucasian subjects (6 males, 11 female) with average age 10.7 ± 3.5. Posturostabilometric evaluation was performed before the beginning of the orthodontic treatment (t0), after 12 ± 2 months (t1) and after 24 ± 3 months at the end of the treatment with FR-2 (t2). The following stabilometric parameters were extracted: weight distribution (WD), bar torsion angle (BTA), and barycenter (Xmm). Both WD ($p = 0.0154$) and BTA ($p = 0.0003$) showed a significant improvement during the treatment with Friedman test and ANOVA test, respectively, showing how the overall balance and weight distribution of the body can benefit from a functional therapy with jaw advancement. The posturostabilometric platform can be considered a functional indicator of therapy effectiveness because it shows the improving trend of the parameters. Future research is needed, based on the promising results obtained in the current study.

Keywords: class II malocclusion; Fränkel; dentofacial orthopedics; interceptive orthodontics; malocclusion; posture

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1. Introduction

Skeletal Class II is a frequent malocclusion in orthodontic practice, and it shows the highest prevalence among Caucasians, both in permanent dentition (23%) and mixed dentition (26%) [1]. Decreased mandibular growth is the most consistent diagnostic finding in Skeletal Class II [2]. It has been reported that the Class II disharmony does not tend to self-correct with growth and an intervention to correct the underlying skeletal discrepancy is therefore necessary [3]. A conservative approach is more indicated for patients in the developmental age, involving a modification of the growth, redirecting the bone bases [4]. Functional appliances are often the preferred modality of treatment in patients with growth potential [5]. Several removable and fixed appliances were proposed to promote mandibular repositioning during growth in the sagittal and vertical direction, resulting in orthodontic and/or orthopedic changes [5]. Functional appliances reduce excessive overjet in Class II malocclusion through dentoalveolar effects, modification of the soft tissue and mandibular advancement, relying on the patient's growth peak [6]. According to a recent review by Moro et al., the skeletal correction of the Class II malocclusion obtained with functional appliances seems to be stable in a long-term observation [7].

The function regulator appliance of Fränkel (FR-2) is a functional orthopedic appliance used to correct Class II malocclusion by advancing the mandible with muscular training [8]. The appliance prevents incorrect muscle function and corrects poor postural behavior of the orofacial musculature during the pubertal phase, characterized by an intense hormonal activity [8]. In a study conducted by McNamara et al. [9], in which no specific appraisals of skeletal maturation were taken into account, less dramatic changes were described in mandibular length between subjects starting FR-2 treatment during the early to mid-mixed dentition (average chronological age, 8.8 years) and those starting during the late mixed to early permanent dentitions (average age, 11.6 years). Freeman et al. [10] demonstrated long-term stability for both skeletal and dentoalveolar changes for subjects treated with FR-2 appliance.

Many studies underline the importance of the muscles in stabilizing the cervical spine and the existence of various connections between muscles in the oral and neck regions. Impaired mandibular growth can affect head posture: most of the studies reported a significant correlation between distal jaw position, sagittal mandibular length, and increased cervical lordosis. Nobili and Adversi [11] demonstrated that subjects with Class II malocclusion exhibit an anteriorly displaced posture, whereas subjects with Class III malocclusion exhibit a posteriorly displaced posture. Therefore a greater extension of the head on the spine is related to a more lordotic curve of the spine and to a Skeletal Class II [12]. According to Tecco et al. [13], functional therapy for Skeletal Class II with a forward jaw repositioning of the mandible seems to cause an increase of the cervical lordosis angle.

The existing relationship between dental occlusion and body posture is a controversial topic in the literature. In 2011, Michelotti et al. published an overview stating that the prevention or treatment of postural disorders cannot justify an occlusal and/or orthodontic treatment [14]. In 2021, D'Attilio et al. introduced the use of posturostabilometric platforms as an aid for the mandibular repositioning treatment in gnathological patients [15].

To our knowledge, this is the first study aiming to investigate the implications of an orthodontic treatment performed in growing subjects on the overall body posture.

The aim of the current study was to evaluate changes in body posture in children with Skeletal Class II pre- and post-Fränkel II treatment, by testing the null hypothesis that no postural changes during orthodontic treatment occurs.

2. Materials and Methods

2.1. Subjects

After taking into consideration the difference in terms of WD in another study, using the same vertical force platform [16], a sample size of 17 subjects was calculated to have at the end of the study a possible statistically significant difference between the observations. The value of α was determined at 0.05 while the Power of the test at 0.80. The website https://clincalc.com/stats/samplesize.aspx (accessed on 3 January 2017) was used for the calculation [17]. Therefore, the sample consisted of 17 children, 6 males and 11 females, with an average age 10.7 ± 3.5 consecutively treated at the Department of Innovative Technologies in Medicine & Dentistry of the University of Chieti-Pescara, Chieti, Italy, from January 2017 to December 2019. This study was conducted in observance of the Helsinki Declaration (revised version of Tokyo in 2004) and Good Clinical Practice Guidelines. Informed consent was obtained from all subjects' parents at the beginning of the study. Subjects' parents gave informed consent at the beginning of the study before confirming that they were fit for this study. Subjects could withdraw from this study for any reason and without prejudice at any time.

The inclusion criteria were: (i) presence of Class II malocclusion with increased overjet (OJ > 4 mm) and mandibular retrusion assessed by cephalometric measurements through ANB angle (ANB > 4°) and WITS appraisal (WITS > 2 mm); (ii) angle class II molar relation; (iii) pubertal growth stage at the beginning of the treatment assessed through the CVM method (stages CS3-CS4) [18], as well as the medial phalanges of the third finger (MP3) method (stages FG-G) [19]; and (iv) compliance during the orthodontic treatment and the posture examination.

2.2. Orthodontic Treatment

All the subjects underwent an orthodontic treatment for Class II malocclusion at the growth spurt with the Fränkel II appliance. A total of 6 out of 17 subjects were contemporarily treated with 2 × 4 fixed appliances in the maxillary arch for correctly upper incisor inclination control (Figure 1). The appliance was designed based on a wax bite impression with the jaw advanced until reaching the edge-to-edge position of the upper and lower incisors. Subjects were invited to wear the appliance at least 12 h per day including nighttime (with a gradual increase in wearing time). The orthodontic treatment lasted until reaching an Angle Class I molar relation and a decreased overjet of about 2 mm. The subjects were monthly visited, in order to assess the integrity of the appliance and renew their compliance by wearing the appliance at least 12 h per day.

Figure 1. Fränkel II appliance and 2 × 4 fixed appliance.

2.3. Posturostabilometric Evaluation

Posturostabilometric evaluation was performed before the beginning of the orthodontic treatment (t0), after 12 ± 2 months (t1), and after 24 ± 3 months (t2) at the end of the treatment with FR-2 with a vertical force platform (Lizard; Lemax s.r.l., Como, Italy). The subjects were carefully placed on the platform with the help of a footprint and some oblique lines drawn on the surface of the platform. In order to ensure greater reproducibility, a tool was made to customize the position of the malleolus [15]. This tool consisted of an elastic band surrounding the patient's ankle to which a wooden stick was fixed. The wooden stick was centered by an operator on the lateral malleolus, so that the center of the malleolus was perpendicular to an oblique line drawn on the platform surface. Another oblique line drawn on the surface of the platform assured the correct rotation of each patient's foot by aligning the heel to the second finger of the foot. The subjects were asked to stay as stable as possible on the platform with their arms along their body and their gaze fixed on a point in the wall 80 cm away, corresponding with the central axis of the platform. The subjects were also invited to keep their eyes opened during the recording. Two consecutive recordings were performed: during the first one, the patient was invited to swallow twice and keep the mandible in a rest position (RP) with no occlusal contact; during the second one, the patient was asked to keep the maximum occlusal contact (OC). Each recording lasted about 60 s. Each evaluation was performed in a quiet room.

2.4. Data Collection

The platform software (Lizard v 3.0; Lemax s.r.l., Como, Italy) processed the signal coming from the platform and the following parameters were extracted: weight distribution (WD), bar torsion angle (BTA), and barycenter (Xmm). The weight distribution (WD) is the difference between the values expressed in kilograms of the projection to the ground of the postural loads divided between the two feet. The bar torsion angle (BTA) is the angle formed by the line that joins the barycenter of the patient with the origin of the Cartesian X axis provided by the platform. The barycenter (Xmm) is the mean value (X-mean) of the lateral displacement of the center of gravity. It is obtained by calculating the mean of the X values obtained during the examination and it expresses the symmetry of the postural tone. The absolute value has a very relative clinical meaning because it can be the result of small variations in the displacements or variations that were way more important than the oscillations. Normal values range varies from -9.6 to 11.7 (mean 1.1).

2.5. Statistical Analysis

Statistical calculation was made by using Prism-GraphPad software (GraphPad software, LLC, San Diego, CA, USA). The Kolmogorov–Smirnov normality test was applied for each of the postural variables considered to check whether data were normally distributed. The sample was normally distributed for the BTA, so the repeated measures ANOVA was applied for this variable. Data with a no-normally distribution (WD and Xmm) were processed with a non-parametric test, namely the Friedman test. Both parametric and non-parametric tests were carried out taking into account the time (t0, t1, and t2) and the conditions of the examination (RP and CO), considering a *p*-value less than 0.05 as significant.

3. Results

The treatment lasts on average 24 ± 3 months and all the subjects reached an Angle Class II molar relation and a decrease of the overjet.

All three parameters analyzed showed a noticeable change demonstrating a postural re-assessment during orthopedic-functional therapy of jaw advancement with Frankel II.

No statistically significant results ($p > 0.05$) were achieved with the Friedman test on Xmm (Table 1) (Figure 2), while there were statistically significant results ($p < 0.05$) were found for the WD (Table 2) (Figure 3). ANOVA test showed statistically significance for BTA ($p < 0.05$) (Table 3) (Figure 4).

Table 1. Friedman test on barycenter (Xmm).

TIME	RP		CO		*p*-Value
	MEAN	DEV. ST.	MEAN	ST. DEV.	
T0	7.7	6.3	7.9	5.4	
T1	7.2	4.0	8.0	3.6	
T2	7.1	4.0	5.6	5.1	0.2741

Legend: RP, rest position; CO, occlusal contact.

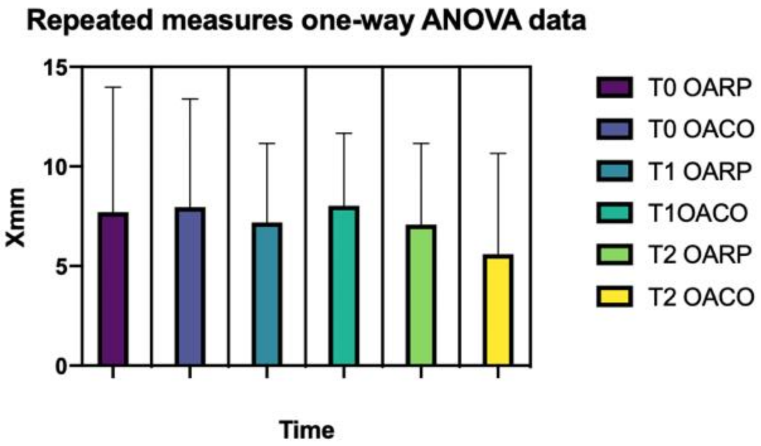

Figure 2. Repeated measures ANOVA mean with standard deviation on barycenter (Xmm).

Table 2. Friedman test on weight distribution (WD).

TIME	RP		CO		*p*-Value
	MEAN	DEV.ST.	MEAN	ST. DEV.	
T0	4.2	3.7	1.7	1.9	
T1	4.6	3.9	1.5	1.4	
T2	3.7	2.5	2.2	1.8	
					0.0154

Legend: RP, rest position; CO, occlusal contact.

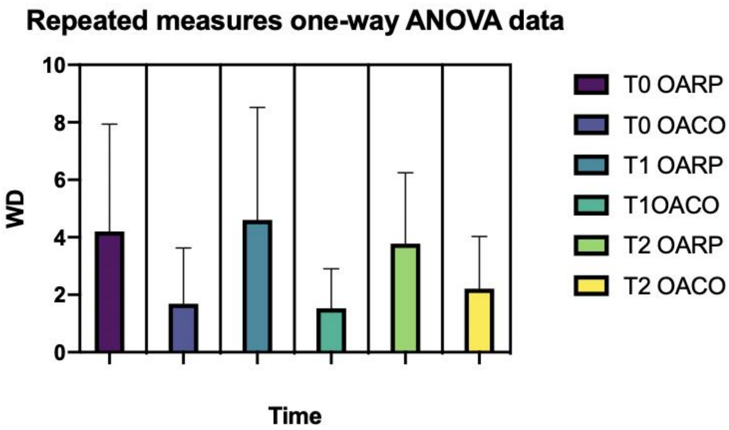

Figure 3. Repeated measures ANOVA mean with standard deviation on weight distribution (WD).

Table 3. Repeated measures ANOVA test on bar torsion angle (BTA).

TIME	RP		CO		*p*-Value
	MEAN	DEV. ST.	MEAN	DEV. ST.	
T0		5.6		5.5	
T1	10.85	4.5	10.3	5.6	
T2	9.1	7.2	8.9	6.2	
	6.04		6.3		
					0.0003

Legend: RP, rest position; CO, occlusal contact.

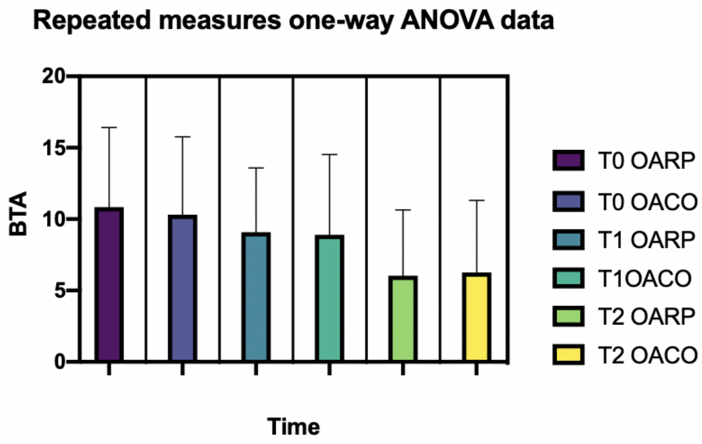

Figure 4. Repeated measures ANOVA mean with standard deviation on bar torsion angle (BTA).

Furthermore, considering the Tukey's multiple comparisons of the repeated measures ANOVA test on bar torsion angle, there is a statistic significancy both for RP and for CO conditions, passing from T0 to T1 (Table 4).

Table 4. Tukey's multiple comparisons of the repeated measures ANOVA test on BTA.

Multiple Comparisons Test	Mean Differences	*p*-Value
T0 RP vs. T0 CO	0.53	0.7687
T0 RP vs. T1 RP	1.77	0.4964
T0 RP vs. T1 CO	1.94	0.5482
T0 RP vs. T2 RP	4.81	0.0195
T0 RP vs. T2 CO	4.57	0.0071
T0 CO vs. T1 RP	1.23	0.6921
T0 CO vs. T1 CO	1.40	0.7913
T0 CO vs. T2 RP	4.27	0.0330
T0 CO vs. T2 CO	4.04	0.0085
T1 RP vs. T1 CO	0.17	0.9998
T1 RP vs. T2 RP	3.04	0.0444
T1 RP vs. T2 CO	2.80	0.0204
T1 CO vs. T2 RP	2.87	0.0521
T1 CO vs. T2 CO	2.63	0.0570
T2 RP vs. T2 CO	−0.23	0.9989

Legend: RP, rest position; CO, occlusal contact.

4. Discussion

The aim of this study was to demonstrate body posture adjustments during functional treatment of Skeletal Class II with FR-2 appliance. All the posturostabilometric parameters examined in this study—except for the Xmm—showed statistically significant changes, leading to refuse the null hypothesis.

Analyzing Tukey's multiple comparisons of the repeated measures ANOVA for BTA (Table 4), a significant decrease of mean values of BTA is noticeable: this can be explained by an improvement of the body twisting. This occurs both for RP and CO conditions, passing from the first to the last evaluation during functional orthopedic therapy.

The progressive decrease of WD represents a reduction of the load difference existing between the two feet and so an improved body balance.

Regarding the Xmm, no important variations were found during the therapy. The lack of significance of barycenter's variation can be due to intrinsic parameter variability and reduced sample size. Furthermore, it has been demonstrated that considerable oscillations and torsions of the barycenter are normally found in growing subjects, due to not fully developed postural systems [20].

The body postural system is a complex kinematic system, composed of a central unit with command function—the central nervous system—which processes and integrates receptor signals: Ocular and feet receptors are the most important ones, but stomatognathic system, joints, and muscles are also involved [21]. In the last years, the dynamic and functional relationship between the stomatognathic system and postural problems is becoming increasingly important due to the proximity between the trigeminal nerve endings and the first cervical plexuses: Marfurt evidenced projections of the trigeminal up in the most caudal portion of the brainstem and at the spinal level up to C5 contralateral and C7 homolateral [22,23].

Many authors have studied patients with malocclusions finding a correlation with spinal deformity: Gonzalez et al. found that the head posture deeply influences the facial growth direction that leads to mandibular postural adaptations and consequently changes in the skeletal growth with dentoalveolar compensation or adaptation [24]. Lippold et al. concluded that the mandible seems to have a greater effect on body posture than other craniofacial parameters [25]. Archer and Vig evaluated the effects of head position on intraoral pressures in adults with Class I and II malocclusions and stated that posture could be an important factor in the development of skeletal morphology and dental position [26]. This can be essential for better understanding the etiology of malocclusions and the prognosis of orthodontic treatments.

However, some studies have not found an important correlation between the stomatognathic system and body posture. Perinetti evaluated if there were postural changes in patients monitored in different visual and dental conditions concluding that no important correlations were found between the two systems, although the existence of a compensation or masking effect on trigeminal receptors by afferences of the postural system could be assumed [27]. Michelotti et al. have suggested that if there is a correlation between the stomatognathic system and posture, it is limited to the craniocervical tract of the column and its effect is reduced as descending along the spine [28]. In addition, Michelotti et al. also reported in their overview that despite the probability of the stomatognathic system affecting the cervical region function, not enough scientific evidence is available to support this relation. It is clear that conflicting opinions can be found in literature about the correlation between posture structures, skeletal craniofacial growth, and dental occlusion [14].

Our study suggests that improvements in body posture are progressive during functional-orthopedic therapy. The absence of a control group clearly represents a major limitation. The comparison between an untreated Class II sample and a group treated with FR-2 could better investigate the influence of a functional-orthopedic treatment on the body posture in growing subjects. However, including an untreated group in a controlled clinical trial could preclude the correction of the malocclusion in this group, because the ideal correction timing—represented by the pubertal peak—would be overcome. Despite this limitation, this is to our knowledge the first study demonstrating postural improvements following orthodontic treatment of jaw advancement.

5. Conclusions

The overall balance and weight distribution of the body can benefit from a functional therapy of jaw advancement. The posturostabilometric platform can be considered a functional indicator of therapy effectiveness because it shows the improving trend of the parameters. Future research is needed, based on the promising results obtained in the current study.

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