日本財団補助金による
２０００年度日中医学学術交流促進事業

③. 中国人研究者・医療技術者招聘助成事業

(7) 重心移動と咬合力、咬合接触面積咬合平均圧及び咬合バランスとの関連

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2. 日本滞在日程

H12年7月　重心動揺計の扱方の修得と計測

H12年8月　デンタルプレスケールによる咬合採得と計測

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H12年10月　咬合と重心動揺の関連性の検討

H12年11月　咬合と重心動揺の関連性の検討

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論文完成

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帰国

重心移動と咬合力咬合接触面積

咬合平均圧および咬合バランスとの関連

(研 究 要 旨)

身体バランスと咬合力，咬合接触面積，咬合平均圧および咬合バランスなどの咬合状態との関係を明らかにすることを目的にした。被験者は，歯列不正と咬合異常のみられない，全身的に健康の成人対象４１名(男子１６名,女子２５名，平均年齢 31.3 歳)である。

方法は咬合状態測定および両足，片足で立つ時の重心動揺測定を実施した。咬合状態測定には，デンタルプレスケール 50H type R(富士写真フイルム社)を用いた。重心動揺測定には，自動姿勢装置 VTS-311，EGG 2000V(Patella 社)を用いた。各起立状態別の咬合力，咬合接触面積，咬合平均圧および咬合バランス点の相関関係について検討したところ，以下のような結論を得た。

1. 身体の重心（足底圧中心点）の平均値は，片足立ちの時は両足立ちの時に比べ有意に軸足の方および前方へ移動した。
2. 両足立時に咬合力，咬合接触面積には非対称性かあり，左右側の咬合力，咬合接触面積を比較するとは有意な差がみられた。
3. 片足立ちの時，重心（足底圧中心）の平均値につれて，咬合中心の左右の移動は有意な差がみられた；しかし，方向は同じでなかった。

本研究結果より，普遍的に咬合の非安定性が有ることがわかだ。今後，口顎機能系と身体姿勢制御系との関係に関して，更に深く検討する必要があるものと思われる。

Key words: デンタルプレスケール　咬合力　咬合接触面積　咬合中心　足底圧中心　非対称性

Influence of Standing Gravity Center's Shift on Bite Force, Occlusal Contact Area and Average Bite Pressure

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Abstract

There are a several hypotheses of correlation between occlusal and postural disturbance. In this study, we attempted to clarify the influence of body's gravity center's moving on bite force, occlusal contact area, average bite pressure and the position of occlusion balance point. Human subjects with normal occlusion and general health were examined with an occlusion pressure graph system and a gravity center measuring system. The information about center of foot pressure, the bite force, occlusal contact area and bite pressure in three standing postures (standing with double feet, stand with right or left foot) was analyzed.

When the subjects stand with only one foot. The center of pressure shifted anterio-laterally to the same side. Comparing to standing with double feet, the difference was significant ($P<0.01$). It had been found that there was an obvious occlusal asymmetry even in the healthy subjects. Significant difference of bite force and occlusal contact area were observed between the two sides when the subjects stood with double feet (bite force, $P<0.01$; contact area, $P<0.05$). The average bite pressure of two sides was not significantly different. As the gravity center shifting, the medio-lateral position of the occlusal balance point moved significantly in most of the subjects (35/41). But the directions were not identical. According to the shift direction of occlusion balance point (medio-lateral axis), the subjects could be divided into four groups. It expressed the instability and multiplicity. No significant differences were detected in other variables among different standing postures.

The results suggested that occlusal instability was very common. Further research is required to explain the relationships between the stomatognathic system and the body regulating system.

Key words

Dental Prescale bite force occlusion contact area occlusion balance point center of pressure occlusal asymmetry

Introduction

With the developing of science and technology, more and more new methods and materials are used to explore the profound mysteries of human being's body. And the

clinicians tend to attention the general relations even more instead of focusing on isolate organs and systems. The problem of gravity center's moving is a region including biodynamics and neuromuscular activities. There are a several hypotheses of correlation between occlusal and postural disturbance. In the last decade these argument have gained a great social impact. As a consequence there have been a growing number of patients seeking concomitant occlusal and postural treatments.

The prevalence of stomatognathic dysfunction syndrome is quite high. A study showed that the temporomandibular joint syndrome was closely related to the asymmetry of masseter muscle activity and only slightly related to the asymmetry of temporal muscle activity. The asymmetry of anterior-temporal muscle's activity appeared little clinical significance. Clenching under conditions of left and right muscle imbalance can further aggravate stomatognathic dysfunction syndrome[1)]. The vertebra is the body's pivot. A survey found that some patients of stomatognathic dysfunction syndrome appeared obviously spinal lateral curvature and the body's center of gravity moved aside obviously[2)].

Although there are some evidences of correlation between occlusion and posture, it appears limited to the cranio-cervical tract of the column and tends to disappear when descending in cranio-caudal direction. Some scholars regard it's not advisable to treat postural imbalance by means of occlusal treatment or vice versa, particularly if the therapeutic modalities are irreversible.

We have to admit that we are really not very familiar to this domain but the success which taken from the treatment of a little amount of cases encourages us to probe further about the correlation between the stomatognathic system and other parts of the body. It is believed that many mysteries are waiting for being discovered.

In order to find that is there any functional relation between the stomatognathic system and the body regulating system. We attempted to clarify the influence of body gravity center's moving on four parameters: bite force, occlusal contact area, average bite pressure and the position of balance point in this study.

Materials and methods

The bite force measuring system

In these years, Dental Prescale system has been developed which is reliable for the

measurement of bite force. Using this system, we can now evaluate the bite force and occlusal contact area on each tooth in the intercuspal position more reliably. This device also enables us to evaluate the bite force balancing point.

The measuring system consists of a pressure-sensitive sheet (Dental Prescale, Fuji Film Co., Tokyo, Japan) and an image scanner (Dental Occlusion Pressuregraph FPD-705 Fuji Film Co. Japan). The sheet, derived from a material used in industrially and known as Prescale, was developed especially for dental use so that its thickness and flexibility would be suitable for measurement of occlusal force. When the sheet is bitten, microcapsules are broken to release staining granules[3]. The occlusal contacts can be detected by a color-developing chemical reaction. Two types of pressure-sensitive sheet are available: Type-R (97um thick) and Type-W (800um thick). The type-R sheet is used for precise measurement of bite force, contact area, and average pressure. The type-W sheet is used for detecting the outline of the teeth and the site of occlusal contacts. Each type of sheet is further divided into two subtypes: 30H and 50H, according to the range of pressure measured. The 30H sheet is used for a range of 3 to 13mPa, and the 50H sheet for a range of 5 to 120mPa. In present study, only Type-R, 50H sheet was used.

The gravity center measuring system

The system consists of a dynamometric platform (VTS-311 EGG 2000v, Patella Co. Japan) and a computer analysis system. This system can measure and calculate the center of pressure (CoP) automatically. The CoP is the vertical projection of the body's mass center (gravity center). It reflects the gravity center's moving indirectly. The system records the moving of CoP for 10 seconds in each phase. The computer can calculate the total distance and area that the Cop moved and the average position of the CoP. We just evaluated the average position of CoP in this research to show the tendency of the gravity center's moving as the standing posture's changing[4,5].

Subjects

41 health adult volunteers (15 males and 26 females; mean age 31.3y, age range 20.5y to 49.7y) with complete dentition except for third molars participated in this study. They exhibited Angle Class I molar relationships without serious teeth crowding or clinical signs of jaw dysfunction. Their general health was well without known musculoskeletal or neurological impairments. All subjects' informed consent was obtained prior to the

investigation.

Data collection and analysis

A. The occlusion samples were collected in three different standing postures:

1) Stand on double feet closing together and the two hands hanged down beside the body and shoulders were parallel to the floor. The head and neck were in natural position.
2) Stand on right foot.
3) Stand on left foot.

In last two postures, the other foot lifted about 10 to 15 cm (the distance between heel to floor), other parts of body were in natural position, no special posture and restriction. In the test design, we wanted to observe the influence of gravity's moving on the stomatognathic system, so no face-bow and support was used.

After a several practice attempts to maintain the intercuspal position, a pressure-sensitive sheet was positioned at the appropriate place in the subject's mouth. The subject was asked to bite in maximum voluntary clenching for 3 seconds. There was 3 minutes interval between two tests. The pressure sheet was place into the occlusion pressure graph within 30 min of being removed from the subject's mouth. After the density of the coloration was converted to a pressure scale, the data of the bite pressure and the occluded area were then transferred to a computer (Windows 95, NEC Computer Inc. Japan). The information about bite force, occlusal contact area and bite pressure was analyzed by means of a software program.

We attempt to estimate force and its location and amplitude. We proposed that the bite force acted perpendicularly to the occlusal planet because of the difficulty of getting accurate information of bite force direction. The anterior-posterior axis of the upper dental arch was located on the middle palatine suture. The medio-lateral axis, perpendicular to the antero-posterior axis, was located on the contact point between the upper central incisors (Fig. 1). All the 41 subjects participated in this part of study.

B. Measuring of center of pressure

The subjects were asked standing quite with eyes open. The feet must put against the base line and the middle line that were marked on the force platform exactly. The test was also divided into three groups:

1) Stood with double feet;

2) Stood with right foot;

3) Stood with left foot.

The other details have been described above. The center of pressure (CoP) in each posture was surveyed and recorded. Then the distance between the CoP and the platform's middle line (X) and the ratio (G) of A to the foot's length (L) were calculate by computer system. A is the distance between the CoP to the connecting line of two feet's heels (Fig. 2). 23 subjects (male 10 and female 13) of the total volunteers were tested in this course. Each one was measured twice in every posture.

Statistical Analyses

All the data were analyzed with SPSS 9.0 for windows statistical package.

ANOVA test was used to examine the difference among the three groups and between two groups classified by posture; and Scheff's F test was used to exam the difference of the bite force, contact area and mean pressure between the subjects' two sides.

Result

1. When a health person stood with only one foot. The center of pressure shifted anteriolaterally to the same side. The difference is significant (Fig. 3.)

Comparing the x-axis position of CoP, ANOVA: $P<0.01$; Comparing the value of G,

D-R $P<0.05$; D-L $P<0.01$; R-L $P>0.05$.

2. The occlusal symmetry is a very important character we want to observe. To determine the preferred chewing side is not very easy. Just declared by the subjects is not exact since some people never mentioned such kind of difference. If you try to observe it, some sensitive subjects maybe can't help changing their normal chewing habit. But just like other parts of body, such as hands, feet, eyes and ears, most people have a preferred chewing side. The difference is just obviously and un-obviously. Actually we observed that most subjects had a stronger side and a weaker side. Significant difference of bite force and occlusal contact area were observed between the two sides of the dental arch in the posture of standing with double feet (Scheff's F test: bite force $P<0.01$; contact area, $P<0.05$). The data of average bite pressure of two sides were not significantly different (Table 1)

3. According to the shift direction of occlusion balance point (medio-lateral axis), the subjects were divided into four groups (Table 2). It expresses multiplicity.

As the shifting of gravity center, the medio-lateral position of the OBP moved

significantly in Group A, B, C (Fig. 4). ANOVA: Group B & C, $P<0.05$ (among three groups); Group A: R-L $P<0.05$; Group B: D-L $P<0.01$; Group C: D-R & D-L $P<0.05$. In other variables of above 3 groups, no significantly difference was found. There wasn't any significant in all variables of group D.

Discussion

The asymmetry of the bite force is due to the activities of the jaw-closing muscle. An investigation[6] found that on the preferred chewing side, the motor units of the masseter muscle appear to differ from those on the non-preferred chewing side. In human body, there are extensive anatomy symmetric phenomena except some internal organs. However most of the symmetric structures appear asymmetry functionally. On the preferred chewing side the teeth had more change to be worn. The contact points changed to small contact planes gradually. If the mean pressure didn't change obviously, when the occlusal contact area increased, the bite force increased accordingly. Tooth contact could bring about a change in the activity of the muscle activity. In another hand the muscle activity would change bite fore, which could affect tooth contact because of physiological tooth mobility. So some scholars[7] indicated that the contact couldn't be simply regarded as either the cause alone or the result alone of the force's change. Each of the two factors, tooth contact and muscle activity has an effect on the other.

In present research we observed that the bite force and the contact area were greater at one side than another side of the dental arch. It seems differ to some previous findings that there was no significant difference of bite force and occlusion area between the two sides at maximal voluntary clenching[6, 8]. Maybe some subjects biting the sheet in sub-maximal voluntary clenching was the main factor that induced the different results. Some studies suggested that the asymmetry of the masseter muscle tend to be greater at lower contraction levels[8, 9]. Different classified criterions used in these researches (stronger side/ weaker side VS prefer chewing side/ un-prefer chewing side) maybe another reason. At the same time, we found that the different between the average bite pressures of the dental arch's two sides was no significant. It's in accord with the previous findings[8, 10].

Bite force, occlusal contact area and average bite pressure are directly observing variables but the occlusion balance point (OBP) is an indirect varible. Although the OBP is not the point at which actual bite force moment is zero, it can be a point that

represents the bite force exerted on all occlusal contacts. At least it's useful for estimating the symmetry of bite force distribution. We found that the OBP shifted as the center of pressure (CoP) moving. But the direction was instability. This result couldn't be compared with previous findings directly because, as we know, there is no corresponding study.

When a person changed his (her) posture from standing with double feet to one foot, the gravity center shifted to the same direction. To maintain the body's balance, there were a chain of neuromuscular activity including legs, arms, trunk and neck. Some studies have examined the functional relationship between mandibular movement and head or body posture. Zafar *et al* certificated that moving of chewing and opening-closing jaw was not only the moving of stomatognatic system muscle but also affect other parts of body[11]. A research of Yamabe *et al* suggested that the head extend-flex motion often accompanied the jaw open-close movement, and the motion of the neck and trunk existed which serve the purpose of promoting the mandible to move smoothly[12]. Eriksson's research showed a functional relationship between the temporomandibular and the cranio-cervical neuromuscular system[13].

In our research a little bit relation was observed. In three groups' subjects (35/41) there was significant different among the distance between the OBP to the antero-posterior axis of three standing postures. Unfortunately, the change's direction seems disorderly; no obvious regulation was founded. It appeared the instability and multiplicity of occlusion. A study of Kim *et al*[14] also reported there was not any significant different between different chair-position in the chewing activities. These results suggested that occlusal instability was very common.

However we can't conclude that the exploring about the relationship between occlusion and body posture is not very significant. It encourages us to explore the deeper and internal correlation. Zafar's study[11] showed that mouth open movement is preceded by extension of the head and that mouth closing is followed by head flexion. Further more, it seems reasonable to believe that such integrated activation of jaw and neck muscles is controlled by a central nervous network common for both jaw and neck muscles. But some other researches indicated that in a standing position, the masseter muscle's EMG activity was significant higher during maximal voluntary clenching; but the EMG activity of sternocleidomastoid did not change. The opposite patterns of EMG

activity supported the idea that there may exist differential modulations of the motor neural pools of the sternocleidomastoid and masseter muscles of peripheral and/or central origin. It suggests that the presence of parafunctional habits and body position could be closely correlated with the clinical symptomatology in these muscles of patients with myogenic craniomandibular dysfunction[15, 16].

There were a several case reports that some patients complained waist and back pain, in clinical examination, the spinal lateral curvature and the unilateral intermaxillary vertical distance's loss were found and their gravity centers shifted lateral. The clinicians inferred that that unilateral vertical loss induced unbalance clenching of stomagtonathic system's muscles and then affected the other parts of body. After improving of occlusion, those general symptoms alleviated dramatically[2]. It illustrated that maybe there were really some functional relationships between the stomatognathic system and body's posture regulating system and they effected in double ways.

When a healthy subject changes his (her) posture from standing with double feet to one foot, the gravity center shifts aside obviously. To maintain the body's balance, a series of reactions appear and many parts of the body are involved. Some researches showed that the displacement of head and lumbar position and the muscles' activity of leg and toes were important factors associated with the center of gravity[17, 18]. The human body has very strong buffering skill. To a specific part, for example, the leg, trunk, neck or the stomatognathic system, the muscular activity changes. However the different is ether obvious or not un-obvious. If the body's normal balance has been broken for a long time, over the limit, neurological and musculoskeletal impairment of some parts will emerge. On the other hand, if the abnormal occlusal relation appeared, the continuing stress is inputted through the sensory nerves. As a feedback, the monitor nerves will adjust to adapt the stimulation. When the type of neuromuscular activity changes significantly, the physical and psychological disorders reflected by this or that kind of symptoms will appear.

The occlusal theory in its original form is based on the findings in adults and assumes that the causal chain proceeds from structure to function. However, the close developmental relationship between function and structure and the recent changes in the functional environment of the stomatognathic organ indicate that the causal influences take place in both directions. During growth, function and structure interact each other.

Conclusion

1 When a health person stood with one foot instead of double feet the center of gravity shifted anteriolaterally to the same side obviously.

2. Even standing with double feet, there was an obvious occlusal asymmetry in healthy persons. The bite force and occlusal contact area in one side of dental arch were greater than in another side.

3. As the shifting of gravity center, the medio-lateral position of the occlusal balance point moved significantly. But the direction was not identical.

The results suggested that occlusal instability was very common. Further research is required to explain the relationships between the stomatognathic system and the body posture regulating system.

Acknowledgement

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Table1. The occlusal station when standing with double feet

	Stronger side	**Weaker side**	**P**
Bite force	826.95±342.59	709.60±300.10	<0.01
Occlusal contact area	23.57±11.17	20.52±12.61	<0.01
Average bite pressure	36.44±5.30	35.74±6.57	>0.05

In the posture of standing with double feet significant difference of bite force and occlusal contact area were observed between the two sides (Scheff's F test: bite force, $P<0.01$; occlusal contact area, $P<0.05$).

Table2. The moving direction of occlusion balance point

Group	n	GC shift to right	GC shift to left
A	13	+	+
B	9	+	_
C	13	_	+
D	6	_	_

Positive indicates that the moving direction of the OBP and the CoP was identical;

Negative indicates that the moving direction of the two points were opposite.

Figure 1

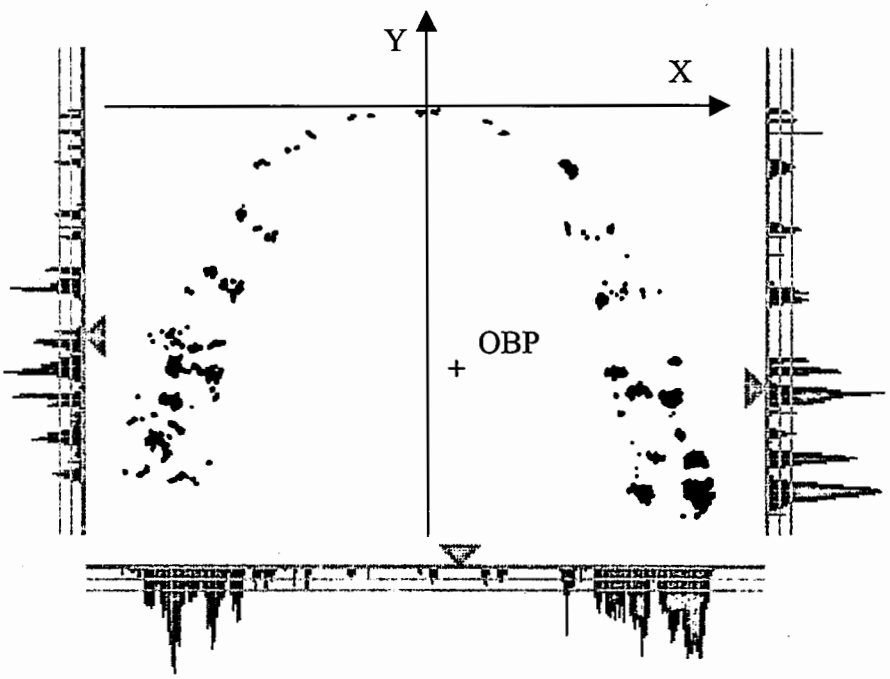

Figure 1. The distribute of bite force

Y axis of the upper dental arch was located on the middle palatine suture. X axis, perpendicular to Y axis, was located on the contact point between the upper central incisors.

Figure 2

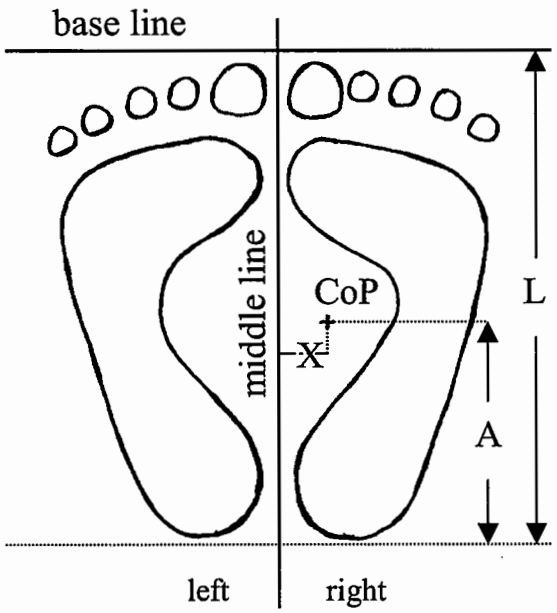

Figure 2 The distribution of foot pressure

X: the distance between the CoP and the platform's middle line
A: the distance between the CoP to the connecting line of two feet's heels
L: the length of foot

Figure 3.

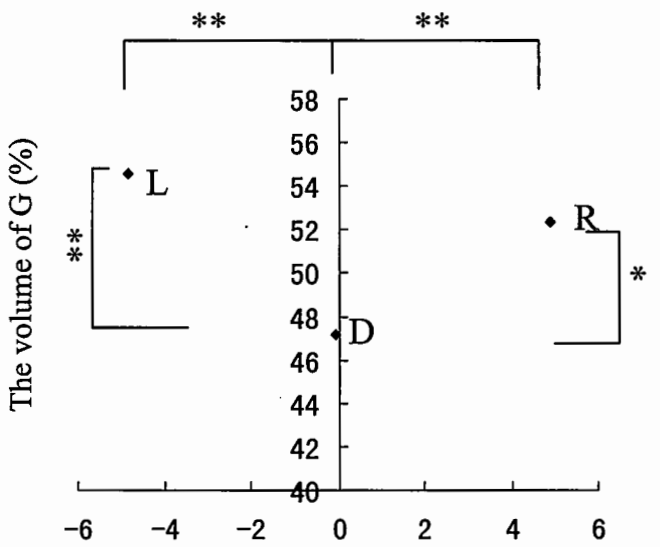

Figure 3. The shift of the center of foot pressure

When the subjects stood with only one foot, the center of gravity shifted to the same side and anterior obviously (N=23, ANOVA: * $P<0.05$, ** $P<0.01$). D: double feet; L: left foot; R: right foot.

Figure 4

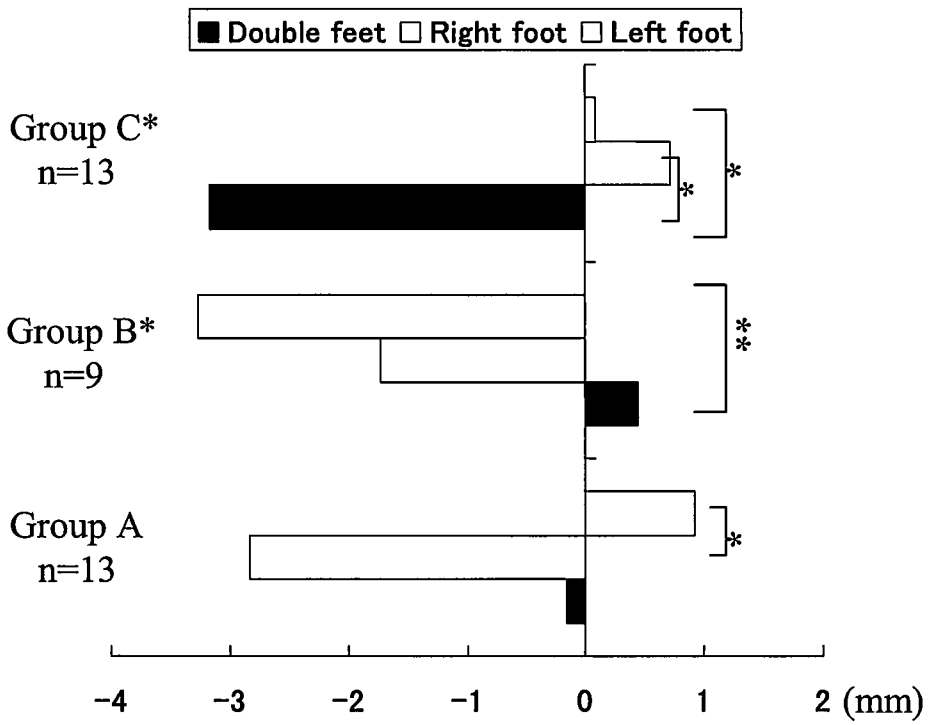

Figure 4. The vary of the occlusion balance point's medio-lateral position

As the shifting of gravity center, the medio-lateral position of the OBP changed significantly in group A,B,C (ANOVA: *P<0.05, **P<0.01)

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