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EXPERIMENTAL USE OF ELECTROMAGNETIC ARTICULOGRAPHY IN A PERSON WITH MYOFUNCTIONAL DISORDER

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Abstract

Using articulography, we can analyse the digital recording of movements and positions of articulation organs (tongue, lips and mandible) during speech production and synchronize them with the acoustic signal. The main research question was to determine whether, the quality of lip and tongue movements change in an individual with a myofunctional disorder and in a control subject? The objective of the research is to measure the significant differences in articulation movements in persons with myofunctional disorder compared to the control subject by means of a three-dimensional measurement of speech movements through the AG501 articulograph. The research design is experimental and due to the difficulty of data measuring and processing, a small research sample was chosen through purposive election. The VisArtico programme was used for qualitative evaluation and visualization of the results. The analysis showed that the extent of the movement of the lips in the protrusion is smaller in the individual with the myofunctional disorder compared to the control subject. The movements of the tongue were equally fast in both people, but they varied with the manner of the articulation. The biggest difference was noticed in the quality of the movements of the lips and articulation of sounds [s] and [r]. The rate of movement of the tongue was not significantly different, but the difference was noted at the place and the manner of articulation.

Keywords: Electromagnetic articulography, myofunctional disorder, experimental study.

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1. Introduction

Electromagnetic articulography is a promising technique used to study the articulators during speech and swallowing. In essence, the technique is a form of an inductive measurement of distance and it's primarily used to kinematically study and diagnose in the fields of motoric and acoustic speech control (Henriques & Leishout, 2013). Using electrodes attached to the articulators (the tongue, lips, lower jaw and the palatum) we obtain the digitally recorded movements and positions of these organs during speech production or swallowing, which can subsequently be synchronised to the acoustic signal. To automatically subtract the effects of the movement of the head, we must first attach two reference electrodes to the head, which ensure the separate generation of the movements of the articulatory structures (Terband et al., 2014; Pattem et al., 2017). AG501 (Carstens Medizineelectronik) is one of the most advanced 3D EMA systems, which provides information about the position of the sensors in the three dimensional planes in Euclidean coordinates - x (horizontal), y (lateral), z (vertical), and in two angles (horizontal and vertical) (Henriques and Leishout, 2013). Using a special type of adhesive we can attach up to 16 sensors onto the articulators. In our case, there is a set of eight sensors (during research only a maximum of 7 sensors is used). The sensors are most often attached to some of the articulators outside of the oral cavity: upper lip (UL), lower lip (LL); and inside of the oral cavity: lower incisor (LI), tongue tip (TT), tongue body (TB), tongue dorsum (TD). The signals are digitized and evaluated through geometric and temporal parameters (Hoole, Zierdt, 2010; Meenakshi et al., 2014). Articulography has already been used several times during the research of speech production, e.g. the study of experimental phonetics (Perkell et al., 1992), the research of coarticulation variation (Bombien et al., 2007); studies aimed on articulatory movements in cases of normal and disordered speech (Schulz et al., 2000; Van Lieshout, 2007) and others. As a result of these studies we have decided to conduct a pilot experiment: to find the significant differences in articulatory movements of persons with a myofunctional disorder compared to the control group, using the measurements from the AG501 articulograph.

Myofunctional disorders (MFD) can also be referred to as orofacial dysfunctions (OFD). Both of these terms describe the differences in appearance, position and mobility of the neck, jaw, cheeks, lips and the tongue. The differences also negatively affect the posture and the complete integrity of the orofacial system (Mason, 2005; Leme et al., 2014). The term myofunctional disorder primarily describes the dysfunction of swallowing in children, adolescents and adults, when the tongue pushes frontally, interdentally, addentally or laterally (Kittel, 2014). Jandová (2010) defines the tongue dysfunction as the incorrect function of the tongue, which has a significant impact on craniofacial development, accompanied with symptoms in the orofacial area, its organ and functional changes, with deficits in breathing and swallowing and characteristic orthophonic changes in articulation. Physiologically, the tongue exerts the force of 1.5 – 2.5 kg, any value under or over this range is a pathological phenomenon which must be removed or at least attenuated through therapy (Fischer-Voolsholz, Spenthof, 2002). The pathological pressure of the tongue causes difficulties during treatment through the removable orthodontic apparatus, i.e. it loosens them from their correct positions and after their removal it continues to press the teeth into their original positions. For this reason, the concept of myofunctional therapy was invented, which leads to strengthening of the tongue and lip musculature, it returns the tongue into its correct resting position and thus develops the palatum durum and the dentes (Korbmacher et al., 2005). MFDs often cause articulatory

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problems, the prevalence of which is estimated at 6-8% in children (Thomson, Polnay, 2002). No standardised test or other valid material has been published so far regarding myofunctional disorders, thus we base our research on the clinical expert evaluations of logopeds, phoniatrists, ENT doctors, orthodontists, neurologists, paediatricians and physiotherapists. Usually, they are evaluated based on the observation of the performance of given movements of the lips and tongue and the complete evaluation of balance and motoric coordination (Bakke et al., 2007).

2. Problem Statement

The exact rate of occurrence of myofunctional disorders is unknown, but a study conducted in Brazil revealed that MFD is prevalent in 87.6% of healthy pupils (Cavalcante-Leao et al., 2017). Due to the fact that there is no standardised diagnostic material for myofunctional disorders, we wanted to find out whether it would be possible to use electromagnetic articulography to diagnose the physiology and pathology of the articulators and the ability to articulate.

3. Research Questions

As a partial objective, we have specified the following questions:

- Does the quality of the lip movement during protrusion and lateropulsion differ between the persons with a myofunctional disorder and the control group?
- What is the quality and speed of the diadochokinetic /ptk/ movement in individuals with a myofunctional disorder compared to the control group?
- Are there any significant deviations during the articulation of the /s/ and /r/ sounds in both of the examined groups?

4. Purpose of the Study

Our objective was to find out whether there are significant differences in the articulatory movements of individuals with a myofunctional disorder compared to the control group, using the measurements from the AG501 articulograph. The possible presence of differences will be observed on the quality of the movements of the lips and the tongue; we will also be observing whether any deviations in the articulation of sounds are present, which tend to be most often disrupted in individuals with MFD.

5. Research Methods

The research design is experimental. The data was measured using the AG501 articulograph, which measures the movement and position of the articulators using electrodes. We wanted to attach the electrodes on the upper and lower lips, and the tip and base of the tongue. Unfortunately, we were unable to attach the electrodes on the base of the tongue in a case of one respondent of the control group due to the gag reflex; we therefore attached the electrode to the tongue midsection. The presence of a myofunctional disorder has been evaluated through an anamnestic and diagnostic questionnaire (Fischer-Voosholz and Spenthof, 2002), through tongue measurements (regarding the length relative to the size of the oral cavity, resp. the

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mandible) and through examination of the frenulum linguae. Each of the respondents has been performing selected oromotoric movements accordingly to the presented pictures from the publication Procvičme si jazýček (Kaulfussová, 2018).

The research sample for the pilot measurement consisted of one person with a myofunctional disorder, and one person as the control group. Both respondents are males aged 28 years, in which an initial diagnosis has been performed, and they were subsequently placed in their respective groups accordingly. Below is stated the substantial information from the anamnesis, diagnostic questionnaire, and examination of the frenulum linguae and measurements of the tongue size.

Male suffering from MFD (MFD-1)

- From the anamnesis: during childhood in the care of an ENT doctor (frequent audis media infections), orthodontist (removable braces due to the rotation of both the upper and lower incisors) and orthopaedist (chest kyphosis). Currently suffering from tonsillitis every year, tends to experience back pain in the area of the cervical vertebrae.
- Size of the tongue is at the limit between small and adequately sized tongue, frenulum linguae is stiffer and unexercised.
- Lips: in resting position slightly parted, thicker and reddened lower lip pointed outwards, accompanying symptoms: frequent lip licking, during swallowing pressed tightly.
- Tongue: in resting position and during swallowing pointed towards upper front teeth, tongue midsection is concave; edges of the tongue show teeth imprints, apparent tremor when sticking out. Stereognosis unaffected.
- Chin: in resting position inactive, during swallowing apparent heightened activity.
- Facial expression: inexpressive
- Teeth, jaw and palatum now without any apparent symptoms
- Breathing is chest heavy, a combination of oral and nasal
- The articulation of sibilants has an addental inclination; the remaining consonants adhere to the codified standards of the Czech language.

Male from the control group(C-1)

- Anamnesis: during childhood has not been in the care of any medical experts, at the present time has no increased rate of illness.
- The size of the tongue corresponds to an adequate tongue size, frenulum linguae is of a standard length.
- Lips: in resting position and during swallowing loosely pressed together, the muscular tension is balanced, without any accompanying symptoms.
- Tongue: in resting position and during swallowing situated in the alveolar ridge, muscular tension and appearance balanced, stereognosis unaffected.
- Chin: in resting position and during swallowing inactive.
- Teeth, jaw and palatum without any apparent symptoms.
- Breathing is chest heavy, primarily nasal.

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- The articulation of sounds adheres to the codified standards of the Czech language.

The results from the tentative examination of the motoric ability of the articulators are stated in Table 01.

Table 01. Tentative examination of the motoric ability of the articulators

Movement	MFD-1	C-1
Protrusion and lateropulsion of the lips	Lateropulsion on the left side accompanied by excessive ocular movement	Unremarkable
Tongue elevation behind the upper alveolar ridge	Only tip of the tongue active with the tendency to roll into the oral cavity, tongue midsection weak	Unremarkable
Suction of the tongue to the palatum	Holds for 1 minute, facial expression apparent at approx. half time, lip protrusion, tongue clicking sounds. Tongue without suction, pressing the tongue to the palatum using tip suction at the palatum durum	Holds for 1 minute, decreasing and increasing the jaw angle during activity, weaker suction after half of the time limit at the left tongue edge
Lateral tongue movement from one commissure to the other	Accompanying movements of the lower jaw and neck musculature, tip of tongue pointed upwards, stable foundation for the tongue formed by the lips	Tip of tongue pointed upwards
Tongue protraction	Tongue held in place using the teeth, tongue tip elevation	Unremarkable
Tongue depressed outside the oral cavity	Teeth imprints apparent on the tongue, tremor of the tongue edges	Tongue rounded, unable to stick out and constrict
Elevation of the tongue outside of the oral cavity	Aided by m. mentalis and the lower lip	Aided by the lower lip

6. Findings

We observed the lip activity during two activities: protrusion and lateropulsion without phonation (five repetitions), protrusion and lateropulsion with phonation (phonation of the sounds /u/ and /i/, again repeated five times). The diadochokinetic tongue movements were observed within the scope of the articulation of the /p/, /t/ and /k/ sounds, while the respondent had to articulate them as fast as possible. Within the scope of articulation we further observed the fastest possible articulation of the /pa/, /ta/ and /ka/ syllables within the duration of 5 seconds. We instructed the respondents to prolong the articulation of the /s/ and /r/ sounds. The gathered information is stated below.

6.1. Protrusion and lateropulsion of the lips without phonation

Within the scope of this task we recorded no significant differences between the two respondents. Both individuals displayed a similar pattern of movement. The biggest range of movement was observed during the third and fourth repetition, the fifth repetition was close to the second repetition with its range. A slightly higher range of lip movement during protrusion was observed in the individual from the control group, although we do not perceive it as a significant difference. This phenomenon will be further observed

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in other individuals. We have observed larger differences when we instructed both clients to repeat the task but in the fastest tempo possible. In this case, the decrease of the range of movement did take place. MFD-1 had the largest range of movement during the first two repetitions and during the last repetition, the movement was less pronounced. C-1 maintained a similar range of movement for three repetitions, and as in the case of MFD-1 performed the last repetition with lesser range.

6.2. Protrusion and lateropulsion of the lips with phonation of the /u/ and /i/ sounds

When performing the movement without a time limit, the range of movement was again almost identical, again no significant differences were observed. Significant differences were observed during the fastest possible articulation of the given sounds. In the MFD-1 client, coarticulation of the sounds took place already during the second repetition, and almost no lateropulsion or protrusion was observed, the lips remained in an almost still position with weak activity. In the C-1 client no significant difference was observed compared to the slower articulation task which took place, the range of movement was approximately 2mm less.

6.3. Articulation of the /p/, /t/ and /k/ sounds

Through this activity we observed the ability of the articulators to perform quick changes of the articulation position. The individuals repeated the entire sequence of sounds five times with no time limit. In C-1, the articulation of sounds was faster with constant articulation position. MFD-1 performed the sequence at a slower tempo but maintained the articulation position as well. A difference has been observed during the articulation of the /t/ sound. In MFD-1 the tongue did not reach such height as in C-1, thus we presume that the articulation position was not the upper alveolar ridge, but the rear surface of the upper teeth.

6.4. Articulation of the /pa/ syllable

The MFD-1 individual performed 26 repetitions in 5 seconds, the C-1 individual performed 34 repetitions. The person with MFD did 8 replications less than person from control group. We repeated the activity twice, with a difference of 7 and 8 replications less than the C-1.

6.5. Articulation of the /ta/ syllable

The MFD-1 individual performed 33 repetitions in 5 seconds, the C-1 individual performed 31 repetitions. We observed no significant difference in the articulation of the /ta/ syllable.

6.6. Articulation of the /ka/ syllable

The MFD-1 individual performed 24 repetitions in 5 seconds, the C-1 individual, however, performed 5 repetitions more. Articulation of the /ka/ syllable was faster for C-1.

6.7. Articulation of the /s/ sound

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We observed different articulation place when articulating the sound /s/ in the MFD-1 and C-1. The tip of the tongue at the MFD1 was built on the teeth while the tip of the tongue C1 was directed toward the lower alveolar ridge. For MFD1, we also experienced increased lip activity and head inclination.

6.8. Articulation of the /r/ sound

The most significant differences between MFD-1 and C-1 were recorded in articulation of the /r/ sound. The MFD-1 individual articulated the /r/ sound with the head inclination, along with the tongue tip, the vibration of the lips and midsection of the tongue was recorded. The position of the tongue fluctuated from the upper alveolar ridge to the lower alveolar ridge and back again. The C-1 individual maintain a constant position of the head, articulation place and constant vibration of the tip tongue.

7. Conclusion

Through the measurement of lip activity, we observed no significant differences. Within the scope of further measurements, we will be observing the range of protrusion during both slow and fast movement in both groups of respondents. In a further examination we will also focus on the fastest possible protrusion and lateropulsion with phonation, where we will be observing whether in further respondents suffering from a myofunctional disorder, coarticulation of sounds would take place. The articulation of the /p/, /t/ and /k/ sounds were performed at a different tempo by both respondents. Again, as a result, the possibility to instruct the clients to articulate the sounds at the fastest possible tempo exists for further measurements, where the speed will be subsequently compared. The quality of movement did not differ during the articulation of the /p/ and /k/ sounds; in case of the /t/ sound, we observed a different articulation position. During the separate articulation of the individual /pa/, /ta/ and /ka/ syllables, an approximately identical performance was observed with the /ta/ syllable. With the /pa/ syllable the performance was different by 8 repetitions, as with the /ka/ syllable the articulation was faster in the case of C-1

Both respondents had problems with articulation of the /s/ and /r/ sounds, while the most difficulties were initially observed with the /r/ sound. In both individuals, we observed a "starting phase", where they first had to figure out, how to vibrate the tongue tip with the electrodes attached. In case of the MFD-1 individual, besides the tip of the tongue, also the tongue midsection was active, which showed smaller scale activity than the tip, but with a similar run-through. Again we can state that the range of movement was almost identical, but the articulation position of the individual sounds was different in both individuals.

Our experiment was a case of a pilot study of the usage of electromagnetic articulography with an individual suffering from a myofunctional disorder compared to a control individual. The measured data will serve as the foundation for further measurements. Our objective is to compare the data from ten individuals suffering from a myofunctional disorder with the data from ten individuals forming the control group. Based on this data we will attempt to determine whether it would be possible to use EMA to diagnose the pathology of articulators.

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