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THE IMPACT OF THE POSITION OF THE HEAD ON THE FUNCTIONING OF THE HUMAN BODY: A SYSTEMATIC REVIEW

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Abstract
The head is an important element of the biokinetic chain. Under physiological conditions, it should extend along the midline of the body. Due to its location and the fact that it constitutes approx. 6% of the total body weight, many authors believe it has a significant impact on its functioning. The aim of this study was to conduct a systematic literature search and to synthesize the evidence of the impact of the head posture on the functioning of the human body. A systematic review was conducted within 3 databases: PubMed, Medline OVID, and EBSCO, using the following terms: "forward head," "posture," "position," and "neck." For the analysis, scientific articles published after 2013 were selected. A total of 16 studies matched the inclusion criteria of this systematic review. Their results have proven that the position of the head has a significant effect on the human body. Research findings show that abnormal head position changes affect muscle activity, proprioception, the pattern of breathing and neck pain. This is the first systematic review of the relationship between the head posture, and the functioning of the human body. The results of this study seem to be promising if used in therapeutic practice. Int J Occup Med Environ Health. 2020;33(5):559–68

Key words:
balance disorders, forward head posture, head, respiratory system, proprioception, neck

INTRODUCTION

The head is an important element of the biokinetic chain. Under physiological and biomechanical conditions, it should extend along the midline of the body. Due to its location and the fact that it constitutes approx. 6% of the total body weight, many authors believe it has a significant impact on its functioning [1]. One of the commonly recognized types of an abnormal position of the head is the forward head posture (FHP) which has been defined as "any alignment in which the external auditory meatus is positioned anterior to the plumb line through the shoulder joint" [2]. Some authors indicate an increasing frequency of FHP in both adolescents and adults. Undoubtedly, this is due to common access and simultaneously longer lasting computer and smartphone usage [3,4]. Despite the high incidence of FHP, there is no standard method for making precise measurements.

In clinical practice, the assessment of FHP is based on visual observations of the position of the head. It is a simple and quick way to estimate the position of the head, but it requires some experience of the person making the assessment [5]. An objective and recognized method of FHP analysis is the photogrammetric method. Many authors perceive it as a highly reliable method [5–7]. For a detailed analysis of the position of the head, the following angles are taken into consideration: the craniovertebral angle

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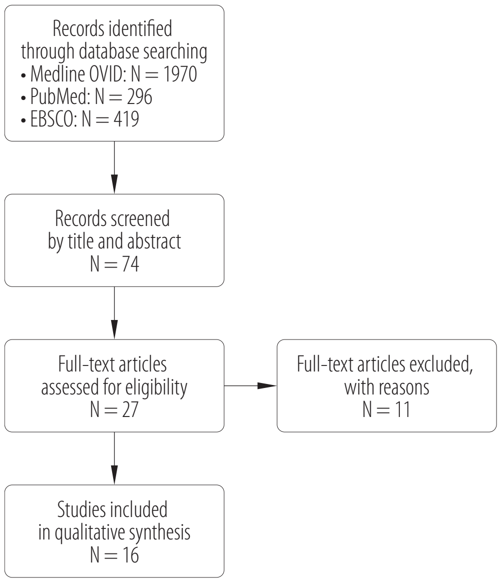

Figure 1. The course of the selection procedure of publications assessing the effects of an incorrect head position on the functioning of the human body, 2013–2019

(CVA), the head position angle (HPA), the head tilt angle, and the cranial rotation angle (CRA) [5].

Many authors emphasize that due to common access to smartphones or computers, and therefore their increasing usage time, the frequency of occurrence of FHP increases every year. Studies have shown that employees using computers significantly contribute to the enlargement of the FHP group [3,4]. According to scientific data, abnormalities in the head posture are absolutely harmful for the human body. The paper was aimed as a systematic review of publications assessing the effects of an incorrect head position on the functioning of the human body. The authors defined the following research questions: whether the position of the head has an impact on the respiratory system; whether the position of the head has an impact on muscle activity; and whether the position of the head has an impact on proprioception and balance.

METHODS

Scientific articles were searched for within the following databases: PubMed, Medline OVID, and EBSCO, on November 4, 2019. Clinical trial articles were included in the search. For this purpose, the following key words were used: forward "head," "posture," "position," and "neck." During the search, Boolean operators "OR" and "AND" were used. Further selection included studying the titles and then abstracts of the publications selected. The next stage was a detailed analysis of the articles and the selection of those in which the impact of FHP on the functioning of the human body was discussed.

For the analysis, scientific articles published after 2013 were selected. Articles on adults, both women and men, were incorporated into the research. Selected were those articles in which the position of the head was measured using objective and reliable methods (Table 1). The considerations included papers whose main purpose was to present the effects of an incorrect position of the head. These excluded both opinion and review articles as well as ones where FHP measurement methods were not used; where the age and sex of the participants were not taken into account, and the criteria for their inclusion and exclusion were not presented; where the focus was on therapeutic activities, not on the consequences of the forward head posture; and where the focus was on studying the behavioral factors associated with the development of the defect and not on its consequences. At the end, 16 publications were selected. The diagram of the selection procedure is presented in Figure 1.

RESULTS

In terms of the main problem being the subject of research, the collected publications can be divided into:

– ones assessing the impact of FHP on the respiratory system,
– ones assessing the impact of FHP on muscle activity,
– ones assessing the impact of FHP on proprioception,
– ones assessing the relationship between FHP and the ability to maintain balance,
– ones assessing the relationship between FHP and neck pain.

Table 1. Publications assessing the effects of an incorrect head position on the functioning of the human body, 2013–2019

Reference	Group		FHP assessment method
	FHP	control	
Anwar et al. [21]	males and females (N = 15), age (M±SD): 23.4±1.05 years	males and females (N = 15), age (M±SD): 23.53±1.18 years	photogrammetry, CVA measurement
Bokaee et al. [16]	females (N = 15), age (M±SD): 24.94±5.13 years	females (N = 15), age (M±SD): 25.18±5.52 years	photogrammetry, CVA measurement
Contractor et al. [25]	males and females (N = 50), age: 30–40 years	–	EPHI, CVA measurement
Han et al. [11]	males and females (N = 14), age (M±SD): 24.3±3.6 years	males and females (N = 12), age (M±SD): 23.3±2.2 years	CVA measurement
Kang et al. [12]	males and females (N = 24), age (M±SD): 29,5±3,9 years	–	CVA measurement
Kim et al. [10]	males and females (N = 33), age (M±SD): 21.5±1.6 years	–	photogrammetry, CVA and CRA measurement
Kim et al. [24]	males and females (N = 22), age (M±SD): 28.55±5.15 years	males and females (N = 22), age (M±SD): 26.64±4.54 years	photogrammetry, CVA measurement
Kim [13]	males and females (N = 14), age: 20–25 years	males and females (N = 14), age: 20–25 years	observational, photogrammetry, CVA measurement
Koseki et al. [9]	males (N = 15), age (M±SD): 26.8±4.5 years	–	observational
Kwon et al. [14]	males and females (N = 40), age: no data	–	observational, photogrammetry, FHA and FSA measurement
Lee [22]	males and females (N = 15), age (M±SD): 22.1±1.6 years	males and females (N = 16), age (M±SD): 21.6±1.1 years	photogrammetry, CVA measurement
Lee et al. [15]	males and females (N = 10), age (M±SD): 21.±1.4 years	males and females (N = 10), age (M±SD): 20.7±1.3 years	photogrammetry, CVA measurement
Lee et al. [20]	males and females (N = 29), age (M±SD): 22.2±1.9 years	males and females (N = 20), age (M±SD): 22.7±2.1 years	photogrammetry, CVA measurement
Szczygieł et al. [8]	males and females (N = 65), age (M±SD): 51±9.8 years	–	photogrammetry (OBE system)
Szczygieł et al. [23]	males and females (N = 62), age (M±SD): 46±6.12 years	–	photogrammetry (OBE system)
Yong et al. [19]	males and females (N = 72), age (M±SD): 22.26±2.10 years	–	photogrammetry, CVA measurement

CRA – cranial rotation angle; CVA – craniovertebral angle; EHPI – electronic head posture instrument; FHA – forward head angle; FHP – forward head posture; FSA – forward shoulder angle; OBE – optoelectronic body explorer.

Criteria for inclusion

The main criterion for inclusion in studies in the publications selected was the diagnosis of chronic FHP. In 14 cases, the photogrammetric method was used and the value of the selected angle indicating the position of the head was determined. Most often it was CVA. It should be noted that there is no precise value of CVA that could indicate FHP; however, most authors take 53° as a limit value. In the other 2 publications, an optoelectronic body explorer (OBE), i.e., a photogrammetric system, was used to assess the position of the head. Some studies included people with a correct posture who adopted forced FHP only for the duration of the study. The adults who qualified for the measurements were free of any diseases or dysfunctions that could affect the reliability of the results (Table 1).

Criteria for exclusion

The main exclusion criteria were similar in all the publications discussed, and included serious illnesses, previous operations and congenital deformities of the spine and chest. In addition, the exclusion factors differed depending on the main topic of the study. With respect to articles on the respiratory system, the criteria for excluding participants were as follows: acute or chronic respiratory diseases, infection with fever within the last 7 days, serious surgical or neurological disorders, as well as smoking cigarettes and taking drugs that could have an effect on the functioning of lungs. In addition, with respect to the articles investigating muscle activity, the excluding factors included: neck or shoulder pain, root pain, musculoskeletal diseases, limb injuries and neurological disorders. The articles related to proprioception and maintaining balance excluded participants with neurological disorders, neuromuscular disorders, dizziness and blurred vision.

The impact of FHP on the respiratory system

Two studies examined how the position of the head impacted on the biomechanics of the chest [8,9]. In both cases, the research methodology was similar. Three-dimensional motion analyzers were used and chest volume changes were measured during natural breathing, maximum inhalation and maximum exhalation. The study conducted by Szczygieł et al. [8] showed that the head positioned in front of the body axis in the sagittal plane caused a decrease in the amplitude of the movements of the lower ribs. Koseki et al. [9] investigated how the shape of the chest changed in the participants when adopting the neutral head position (NHP) as well as the position where the head was maximally forward (i.e., FHP). The measurements showed that with FHP the shape of the chest changed significantly. The upper part of the chest expanded and the lower part compressed. In addition, these studies showed that the mobility of the lower chest during breathing was limited, especially in the anteroposterior direction, which is consistent with the observations by Szczygieł et al. [8].

Respiratory parameters indicating lung function were measured spirometrically in 4 studies [9–12]. In each of them, parameters such as forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV_1) were determined. In 3 papers [10–12], the results of these measurements were correlated with the CVA value in people diagnosed with chronic FHP. Han et al. [11] additionally compared them to the values of the control group. The spirometric parameters assessed were significantly lower in the FHP group than in the control group, for both men and women. Koseki et al. [9], on the other hand, compared FVC and FEV_1 for the same person after they adopted NHP and forced FHP. In all of the publications mentioned above, there was a significant reduction of FVC and FEV_1 in the subjects with FHP.

In addition to FCV and FEV_1, 2 papers analyzed other parameters as well. Koseki et al. [9] analyzed changes in inspiratory reserve volume (IRV) and expiratory reserve volume (ERV) as well as peak expiratory flow (PEF) for a given patient in neutral and forced FHP. These parameters were significantly lower in the case of FHP. The authors argued that the extension of the upper chest in the head-forward position seemed to limit its contraction during exhalation, and consequently reduced ERV, FEV_1 and PEF. Conversely, the narrowing of the lower chest in FHP may limit its expansion during inspiration and cause losses in FVC and IRV. Kim et al. [10] studied the effects of FHP on vital capacity (VC), PEF, i.e., the maximum airflow velocity during increased exhale, and maximum voluntary ventilation (MVV), i.e., the air volume exhaled in 1 min during breathing as quickly and as deeply as possible. The analysis of the results showed a statistically significant positive correlation between CVA and the parameters mentioned above. This shows that when reducing CVA, the forward head posture becomes more advanced and the respiratory functions decrease.

The impact of FHP on muscle activity

In 6 of the articles analyzed [10–15], surface electromyography (EMG) was used to measure skeletal muscle activity. The electromyographic signals from the muscles were registered and analyzed using specialized software. Muscle activity was expressed as a percentage of the maximum voluntary isometric contraction.

In 3 publications [10–12], the surface EMG of the accessory muscles of respiration during breathing was examined. The subjects were asked to take a comfortable sitting position, and then to breathe naturally [10–12] or deeply [10,11] for 10 s. To calculate the root mean square, parameters registered between 2 and 8 s, during the measurement lasting for 10 s, were used [10,12]. By the study conducted by Han et al. [11], the exact procedure was not presented.

In 1 study [16], muscle activity was not studied directly. Instead, changes in the thickness of muscle fibers were studied. For this purpose, rehabilitative ultrasound imaging was used.

The analysis of the collected work indicates that a change in the position of the head causes changes in muscle length and performance. Deep neck flexors become weaker and neck extensors become shorter. In addition, superficial muscles, such as sternocleidomastoid (SCM) muscles, show increased activity [10,17]. It may be surprising that the results of individual muscle activity were different in some of the publications. Kwon et al. [14] studied muscle activity in people with FHP when they adopted certain postures. The results showed that the activity of the anterior and upper quadratus muscles was increased when the participants were in their natural position compared to the corrected position. This can serve as a proof that posture correction affects the normalization of tension.

Kim [13] investigated the differences in neck kinematics and SCM muscle activity during rotation in healthy people and in people with FHP. For precise rotation, proper neck control is important. The author speculated that, as a result of changes in the length of muscle fibers associated with this defect, the rotation would be hindered. The results showed that people with FHP had a greater range of movement than healthy people. These results were inconsistent with earlier studies by Quek et al. [18]. However, Kim observed that in patients with FHP there was a lateral flexion component during the rotation movement, which was probably the reason for the seemingly greater rotation movement. At the same time, EMG measurements showed that there was an increased activity of the opposite SCM muscle during rotation in the study group.

Different results were observed in the study conducted by Lee et al. [15]. In that study, a decreased activity of SCM and trabecular muscles was observed in people with FHP when compared to the control group. This difference was observed when the subjects performed neck protraction. No changes were observed during the retraction. The authors argued that this was caused by the muscle ability to generate strength being dependent on its length. When the muscle is shortened, as is the case with FHP, its ability to generate strength is reduced. There was no difference in the activity of the upper part of the trapezius muscle, probably because the muscle does not play a role in protraction and retraction movements.

In 3 studies included in this analysis, the authors correlated the activity of additional respiratory muscles with lung functions. In the paper by Kim et al. [10], the results showed that FHP was negatively correlated with respiratory functions, and positively with the activity of additional respiratory muscles, such as the SCM muscle and the anterior scalene muscle. The authors suggested that patients with FHP showed a chest breathing pattern, thereby increasing muscle fatigue due to excessive use. In the study, a decrease in respiratory parameters such as VC, FVC, FEV_1, PEF and MVV was observed along with a decrease in CVA. The study confirms that the more advanced FHP, the greater the activity of the additional respiratory muscles and the more limited the respiratory function.

Kang et al. [12] arrived at similar conclusions. Their study also showed increased activity of the SCM muscle during breathing when FHP was more advanced. At the same time, it was observed that the more advanced FHP, the lower FVC. In contrast, studies by Han et al. [11] showed reduced activity of additional respiratory muscles in people with FHP compared to the control group. This difference may be due to the fact that in the Han et al. study, muscle activity was measured during deep breathing. These authors observed lower values of respiratory parameters such as FVC and FEV_1 in the study group compared to the control group. In the 2 articles analyzed here, the authors hypothesized that the respiratory function was also affected by the shape of the chest, which might change as a result of FHP.

The impact FHP on proprioception

Of the many body structures located in the cervical region, muscles are considered to be the main element responsible for the sense of position due to many proprioceptive receptors. Some authors assumed that the muscle balance disorders in patients with FHP could lead to the disruption of the afferent signal from the muscle spindles, which can have an adverse effect on the sense of joint position [19]. Three publications were analyzed which examined whether there was a relationship between FHP and proprioceptive activity [19–21].

In order to assess proprioception, the authors of the cited publications investigated the value of the sense of position error (or joint position error/repositioning error). Yong et al. [19] used a digital inclinometer in their studies. The test procedure required the participants to adopt a neutral starting position. Then, after the proper placement of the inclinometer, the subjects performed the maximum range of flexion and neck extension movements for about 5 s, and then returned to the neutral position as they remembered it. Lee et al. [20] performed a test in which the subjects were instructed to put on a helmet with a laser pointer attached to it, and to adopt a natural rest position so that the laser beam projected onto the target. With closed eyes, the participants performed the full range of flexion, extension and rotation of the neck, and maintained the final position for 5 s, and then returned to the starting position. The point where the laser beam stopped was marked with a dot. The absolute error value was measured as the distance between the 2 selected points.

In both works [19,20], the obtained results were statistically significant. Yong et al. [19] demonstrated that there was a significant negative correlation between CVA and the sense of position error for flexion and extension movements. The reduction of CVA, i.e., the increase in the severity of FHP, caused an increase in the joint position error. Similar results were obtained in the study performed by Lee et al. [20]. Additionally, in their work, significant differences in all neck movements (bending, extension and rotation) between the study group and the control group were observed. Significantly higher joint position error values were noted in the group with FHP, compared to the one without this postural defect.

Anwar et al. [21] conducted research to find out whether FHP affected the proprioception of the shoulder. The aim of the study was motivated by the fact that the head posture might also affect more distant structures, such as the thoracic spine, shoulders and arms. An active repositioning test was carried out to examine the participant's ability to actively reproduce the established shoulder setting with one's eyes closed. The anatomical reference angle was set to 75° of external rotation. The results obtained by the authors did not show a significant difference between the study group and the control group. However, the authors emphasized the fact that the participants demonstrated a mild form of FHP, and that the severity of the defect might play a role.

In the article by Lee et al. [20], higher levels of the sense of joint position error in the group of FHP patients in all neck movements (bending, extension and rotation) were noted, together with a correlation between this parameter and the degree of FHP. These results suggest that FHP affects the sense of joint position, which is worse when the defect becomes more severe. The described conclusions are consistent with the study by Yong et al. [19] who investigated proprioceptive function in patients with FHP during bending and neck extension. There was a negative correlation between CVA and the joint position error. The sense of joint position is considered to be a component of proprioception. It is understood as the ability to sense the joint position, and it affects both the body alignment and joint stability. This sense is particularly affected by receptors located in the muscles, i.e., muscle spindles. Therefore, the results of the research indicate that a deteriorating ability to sense the joint position is the result of changes in muscle length that occur in subjects with chronic FHP [19,20].

The relationship between the position of the head and balance

A defect posture of the head may disturb the sense of body posture and balance, which has been proven in numerous studies [19,20,22,23]. Lee et al. [20] examined the impact of FHP on the ability to control static and dynamic balance. The static balance control was assessed using a specialized system that measured the speed and amplitude of the center of gravity (COG) sway. The measurements were made on both hard and unstable surfaces with one's eyes both open and closed. Furthermore, a system for measuring and training stability was used to assess the dynamic balance control. The subjects stood on a platform that tilted up to 30° (2°/s) in 8 directions. The participants had to keep the initial position of the body, depending on the tilt of the platform. The ability to maintain the position was assessed by measuring torso sways.

The differences in the results of the dynamic balance control between the control group and the study group were not significant. However, significant differences were observed between the 2 groups when maintaining the static balance. The velocity and total distance of COG sways, both with one's eyes open and closed, were significantly higher in the group with FHP than in the control group. The difference was registered when performing the measurements on a stable surface. On an unstable surface, the velocity of COG sways was higher in the study group only when measured with one's eyes closed. No difference was observed within this parameter when the eyes of the subjects were open.

In the article by Szczygieł et al. [23], the position of the head was assessed using OBE which allows one to determine the spatial coordinates of any points of the body using specially placed markers. A pedobarographic platform was used to assess the stabilographic variables. The tests were carried out in a standing position, barefoot and with one's eyes open. With the subjects standing on the platform, the center of pressure sways and the COG movement were both recorded. Despite the noticeable negative correlation, the results did not show a significant impact of head position changes in the sagittal plane on the stabilographic variables. However, when taking into account the location of the head with the torso in the sagittal plane, the authors noticed that a greater angle of inclination of the torso caused an increase in the COG sways, which meant a decrease in stability. Interestingly, it was observed that even an isolated change of the head position in the frontal plane significantly influenced the value of stabilographic variables.

The relationship between FHP and neck pain

In the study conducted by Kim et al. [24], persons with CVA <52° were qualified to participate. They were divided into 2 groups: ones who reported neck pain and ones who did not. The range of neck movements of the participants was examined (bending, extension, rotation to the right and to the left). The obtained results showed a significant reduction of CVA, and the extent of flexion and neck extension in the group reporting neck pain. However, no significant difference in rotational movements was noticed. The results obtained by Contractor et al. [25] also indicate that in persons suffering from cervical pain an increased FHP can be observed.

When comparing FHP in people with pain and without pain, Kim et al. [24] reported that the participants experiencing pain had a reduced range of neck movements and lower values of CVA. Similarly, in the studies by Contractor et al. [25], there was a negative correlation between CVA and neck pain. This means that people with more advanced FHP suffer from greater pain. As claimed by the authors of this study, it is difficult to say unequivocally that neck pain is a consequence of FHP. It is known, however, that an incorrect position of the head causes an increased load on the cervical spine and results in changes in the length of the muscles, which would confirm that the pain is a result of an incorrect posture.

DISCUSSION

From the physiological point of view, the head should be located at extension of the midline of the body. Unfortunately, head orientation changes are a common phenomenon. Szczygieł et al. [7] showed that only a small number of people met the criteria for the proper head posture. Among 65 study participants being examined, only 5 patients had a normal head position in the sagittal plane, 7 patients in the transverse plane, and 20 patients in the frontal plane. Also Salahzadeh et al. [5], observing 78 women with an average age of 23, did not determine FHP in terms of only 15% of them. Because of a special role of the head in the motor system, the paper was aimed as a systematic review of scientific articles on the impact and consequences of FHP on the functioning of the human body.

The findings of the current studies indicate that the head moving forward activates a number of compensation mechanisms involving many structures. Failure of the head to align with the vertical axis of the body, among others, causes disturbances in the 3-dimensional chest shape and its respiratory movements, decreases their respiratory movements of the lower chest, and increases the amplitude of respiratory movements of the upper tract [8,9]. The literature contains some scientific evidence that this phenomenon is not inert to the function of the lungs themselves because it leads to a reduction of spirometric values [9–12]. The authors believe that this fact should be taken into account in procedures aimed at re-education of both posture and breathing patterns.

Studies concerning the consequences of the head position on muscle activity constitute a kind of extension of the topic of the impact of the head position on respiratory functions. They confirm that changes of the head position lead to accessory muscle recruitment with increased, among others, SCM and anterior scalene muscle activity causing rib cage elevation and reducing thoracoabdominal mobility [10,17]. Therefore, it seems that the logical consequence of this series of events would be cervical spine overload syndromes. Alteration in the head posture, muscular imbalance has been observed in the neck pain population [24–26]. Chiu et al. [26] showed that about 60% of people with neck pain had FHP. However, future studies are needed to find the answer as to which comes first, neck pain or FHP.

Due to the large number of proprioreceptors located in the neck area, the head position also has a significant relationship with balance. Additionally, as the head moves forward, COG shifts. According to many authors, it is the reason for body position disorders and worse balance among people with FHP [19,20,22,23]. It seems that the results of presented studies should be helpful in prophylactic and therapeutic practice.

It should be emphasized that the studies analyzed here have certain limitations. First of all, only in 1 study [11] the results were broken down in terms of sex. In most of the papers, people aged around 20 were evaluated, but studies on elderly participants were also taken into account. In some articles, there was no distinction between the study group and the control group [8,10,12,14,19,25], but all the participants had FHP, and the results were correlated with the values of HPA. The papers analyzed here were published in 2013–2019. In consequence, the focus was on the results of studies that are in line with the latest knowledge. However, such a selection resulted in there being only a few papers discussing the relationships between FHP and neck pain or muscle activity, because such relationships had been widely studied in earlier years.

CONCLUSIONS

In people with FHP, abnormalities in the breathing movements of the chest as well as in respiratory functions, especially FCV and FEV_1, can be observed.

Changes in muscle activity caused by a chronic abnormal head position negatively affect proprioception and the stability of the body.

Changes in muscle activity caused by a chronic abnormal head position result in an increased occurrence of neck pain.

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