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The Technique of Extracting and Detecting Athletes' Oral Odors Based on the Analysis of Biological Characteristics

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The athletes' oral odors are directly related with physiological factors such as large amount of exercise and mental factors such as mental stress. As a kind of human body odor, oral odors have a series of characteristics such as stability, uniqueness, simplicity of feature extraction and convenience, which can be used as the basis of disease diagnosis. Based on the biological characteristic analysis technology, this study analyzes the extraction and detection techniques of athletes' oral odors. The stability of exhaled gas of individuals is verified by odor chromatography. The results show that the similarity of exhaled gas chromatograms of the three groups in 30 days keeps about 88% on average, which indicates that the oral odors of the athletes remain stable. In the electronic nose system, the Linear Discriminant Analysis and Principal Component Analysis are used to classify diseases associated with oral odors. The results show that Linear Discriminant Analysis is superior to Principal Component Analysis in classifying patients with diseases and healthy people, which provides technical support and theoretical basis for exploring athletes' oral odors and their physiology, as well as its relationship with mental problems.

1. Introduction

Oral odors (Rosenberg, 1996) have brought great troubles to athletes' physical and mental health and social intercourse. In serious cases, even mental illness or social disorder may occur therefrom. Athletes usually do not have a clear sense of the odors produced by their own oral cavity, but rather have a strong reaction to the odors by other people's oral cavity. Therefore, the evaluation of their own oral odors (Oliveira-Neto, 2013) needs to be judged by objective evaluation of others or by professional instruments. Oral odors are sometimes only mental and sometimes temporary, but athletes’ oral odors are an important indicator of physical health (Migliario, 2011) and are early symptoms of certain diseases (Rosenberg, 2006), such as gastrointestinal diseases, diabetes (Calloway, 1969), liver diseases and other diseases, which occur with oral odors. There are many factors causing oral odors (Cao, 2006), so when the athletes have oral odors, they can find out the causes of the oral odors through the test (Wang, 2009) to solve the problem fundamentally. Therefore, the extraction and detection of oral odors is of great significance in social practice.

At present, the common detection methods are direct method and indirect method. The direct method includes sensory analysis and scientific instrument detection while the indirect method is to indirectly assess by measuring the volatile organic compounds in the oral cavity. At present, such chemical instruments as electronic nose technology (Fend, 2006), spectrometer (Jamrógiewicz, 2012) and chromatograph (Manz, 1990) can be used to collect and detect oral odor. Electronic nose technology (Thaler, 2001) simulates the reaction of human body to one or more smells. Despite of simple and convenient operation, it cannot accurately identify the components and content of oral odors. The odor chromatograph can analyze the components and content of exhaled gas in oral cavity with higher accuracy, but the instrument is relatively complex and time-consuming. Based on the analysis of biological characteristics, this study analyses the extraction and detection techniques of oral odors, and provides technical support and theoretical basis for exploring the relationship between oral odors and physical diseases.

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2. Theoretical Basis

2.1 Biometric identification technology

Biometric identification technology is to use the inherent behavioral characteristics and physiological characteristics of the human body to identify and appraise the identity. In general, human physiological characteristics are innate and do not change obviously. At present, the fingerprints of human hands and feet, the retina of human eyes, DNA and human smell are widely used physiological characteristics of human body (Ribaric, 2005; Zhang, 2018). Not all biological characteristics can be used for identity recognition and authentication (Gibbs, 2010), and only the characteristics satisfying certain properties can be used as criteria for distinguishing, as shown in Figure 1. In addition to the following characteristics, in the actual extraction and detection process, such factors as accuracy, simplicity and timeliness of characteristic extraction, as well as whether to harm human health are considered.

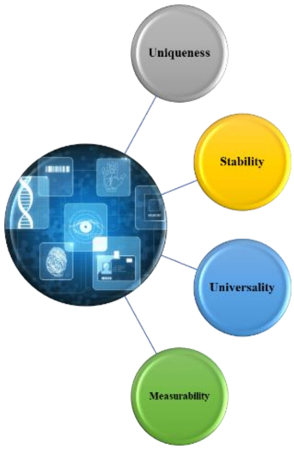


Figure 1: Characteristic of biometric identification

2.2 Human smell

The smell is a tiny substance emitted by the human body and floating in the external environment. It maintains relative stable in a certain time and space, and cannot be perceived by the eyes, ears and touch. Only when the concentration reaches a certain amount can it be sensed by the olfactory cells. The human body continuously emits smell to the outside world through the mouth or skin. Each person's smell is unique and is closely related to a person's genetic material, physiological function, health status, living environment and so on, so it can be used for individual identification. In addition, the human smell has the advantages that it cannot disappear and cannot be tampered with.
The main parts of the human body's smell are mouth, armpits, head and feet. In fact, the body's secretions have no smell themselves, just because there are corresponding microbial communities in these sectors. Therefore, the human smell is caused by the joint action of human skin’s secretions and various microbial flora. The following table lists some basic substances such as aldehydes, acids and alcohols contained in the human smell.

Table 1: Basic substances contained in human smells

Name	Category
2-Propanone	Ketone
Toluene	Aromatic substance
Hexanal	Aldehyde
Butane	Halogenated hydrocarbon
Decane	Hydrocarbon
2-ethylhexanol	Alcohol

3. Extraction and Examination Technique of Oral Odor

3.1 Oral odors

Oral odors mainly refer to the unpleasant smells emitted from oral cavity or nasal cavity. At present, about 20%~60% of people suffer from oral odors. As a symptom of diseases, they will have great influence on

people's life and work, social disorder and even suicidal tendency in serious cases. The causes of oral odors are shown in Figure 2.
As shown in the figure, pathological oral odors are classified into oral and non-oral odors, of which about 80% of oral odors are caused by oral diseases. Oral factors include tongue coating, periodontal diseases, infection associated with oral mucosal lesions, and the presence of volatile sulfur compounds and fatty acids produced by a large number of bacteria in the oral cavity due to the long-term use of certain drugs. Non-oral factors refer to oral odors caused by diseases outside the oral cavity, such as gastrointestinal diseases with sour taste in the oral cavity, diabetes with rotten apple taste, and upper and lower respiratory diseases with rotten taste.

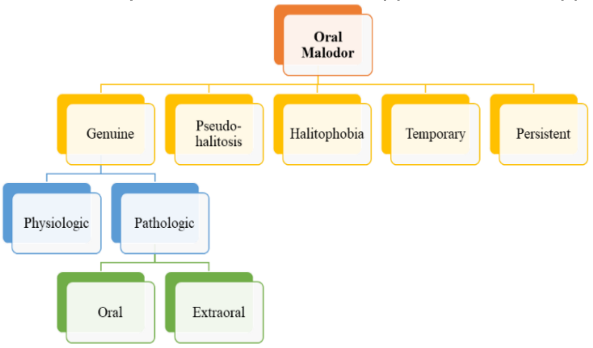


Figure 2: Classification of oral odors

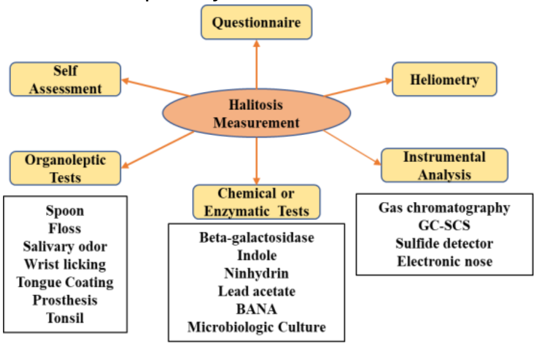


Figure 3: Method for diagnosing oral odors

3.2 Examination methods for oral odors

At present, there are various methods for diagnosing oral odors, such as self-evaluation, sensory analysis, instrument detection, and biological analysis as shown in the Figure 3 above.

3.3 Feature extraction of oral odors

In the process of feature extraction of oral odors, we first collect the gas, let the exhaled gas pass through some sensor groups composed of different functions, and then the sensor converts the signals to carry on the subsequent analysis and research. On the one hand, feature extraction can eliminate the irrelevant factors, reduce the dimension and improve the accuracy of the model, and on the other hand, it can simplify the model greatly, thus reduce the calculation amount and calculation time, and improve the detection efficiency. Several methods commonly used in feature extraction include:

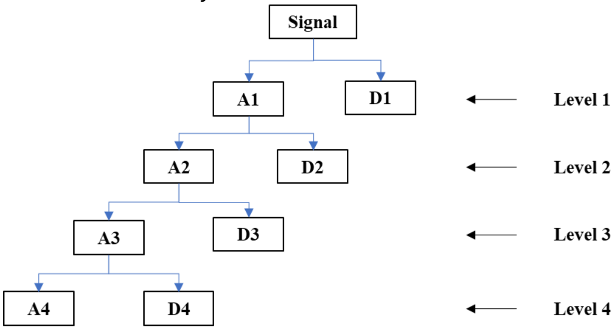


Figure 4: Schematic diagram of wavelet decomposition process

(1) Geometric feature method: It is a simple and fast method to describe the type and concentration of gas by visually extracting the geometric feature of sampled data.
(2) Principal Component Analysis: It is a method of ignoring high-order components by keeping the feature of contributing the difference the most in the collected data, which is advantageous for aggregating the same kind of samples.
(3) Wavelet decomposition: The signal collected by the sensor is represented by a finite length or fast attenuation wavelet, so that more low-frequency parts containing features can be obtained, and the decomposition process is shown in Figure 4.
(4) Linear Discriminant Analysis: By projecting samples from high-dimensional space to low-dimensional space, the dimension is reduced, and the purpose of simplifying the model to classify gases is achieved.

4. Experimental Study on Extraction and Detection Techniques of Oral Odors

4.1 Experiment on the stability of oral odors

Although everyone's smell is unique, when the oral odor smells, it can largely reflect a person's physical health, and the smell is stable for a certain period of time. We validate the feasibility of using oral odors to diagnose early diseases by continuously sampling the oral odors exhaled by patients with certain diseases and analyzing changes in contents of certain characteristic gases.

4.1.1 Experimental method

This experiment randomly selects a healthy athlete of track and field team, a diabetes patient and one patient with kidney disease, collects the breath samples of the subjects in the same time period every other day for 30 consecutive days, and then analyze the collected respiratory gas samples with the odor chromatography technology (GC/MC) to explore their stability over a period of time. The components of the gas exhaled by the human body is various and complex. We choose several substances with higher content to study whether their chromatograms are different.

4.1.2 Experimental result

Figure 5 is a chromatogram of one-day exhaled gas in diabetic patients selected in this experiment. It can be found that its chromatographic peaks are mainly concentrated in 5min to 35min, and the content of various substances is different, so the peak value of each substance concentration is also different. For diabetic patients, the characteristic gas is acetone and for nephrotic patients the characteristic gas is ammonia gas. By comparing the chromatogram of 15 exhaled gases within 30 days, it was found that the peak values and substances of each chromatogram are basically similar without too much change.

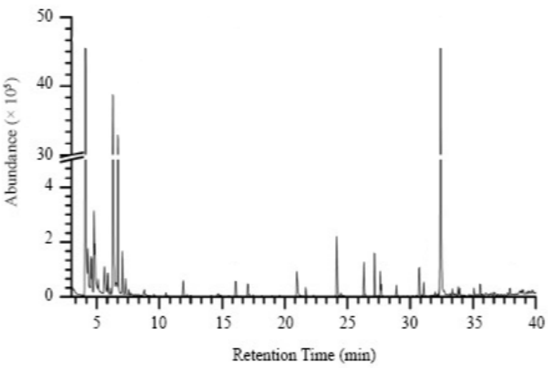


Figure 5: Chromatogram of diabetic patients

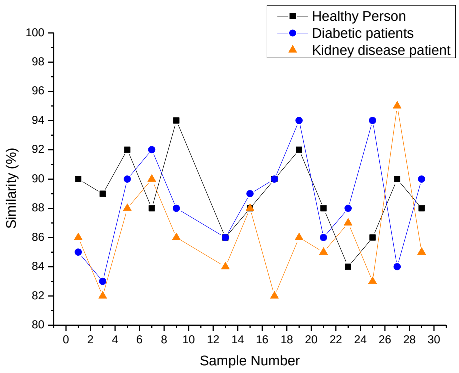


Figure 6: Chromatogram similarity change for 30 Days

In order to further judge the stability of oral odors over a period of time, we use computers to calculate the similarity of chromatograms. The closer the results are to 100, the higher the similarity is. Sample No. 7 of the samples is randomly selected as a standard to be compared with other samples, and results are obtained as shown in Figure 6 (Dominguete and Takahashi, 2018).
The results show that the similarity values of the three groups range from 82% to 94% and the average value is about 88%, which indicates that the single individual has a very high similarity in 15 chromatograms for 30 consecutive days, and the oral odor of human body is stable in a period of time and could be used as the basis for early diagnosis of diseases.

4.2 Classification of diseases associated with oral odors

4.2.1 Experimental method

This experiment mainly uses the electronic nose system to collect and analyze the exhaled gases in oral cavity. The working flow of the electronic nose is shown in Figure 7. After pre-processing the collected data, based on curve fitting parameters, the classifications of diseases associated with oral odors by Linear Discriminant Analysis and Principal Component Analysis are compared. The number of experimental samples required for this experiment is shown in Table 2.

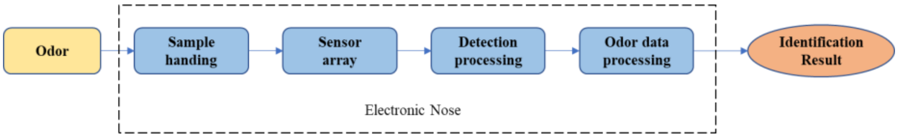
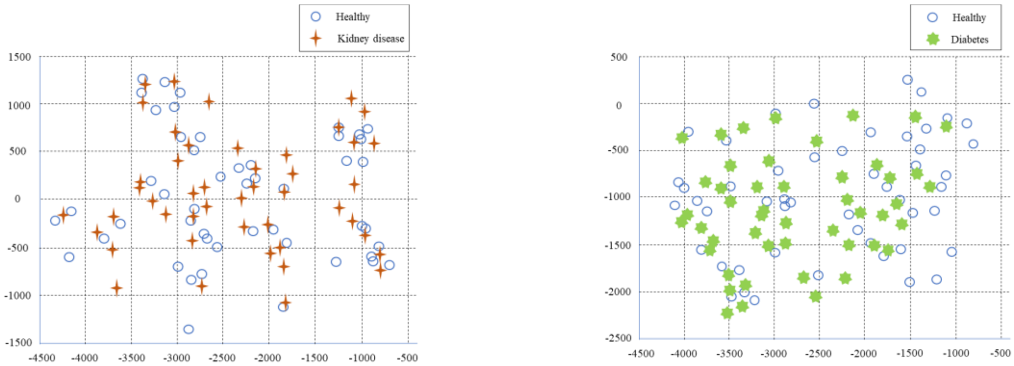


Figure 7: Oral odor detection system

Table 2: Sample information

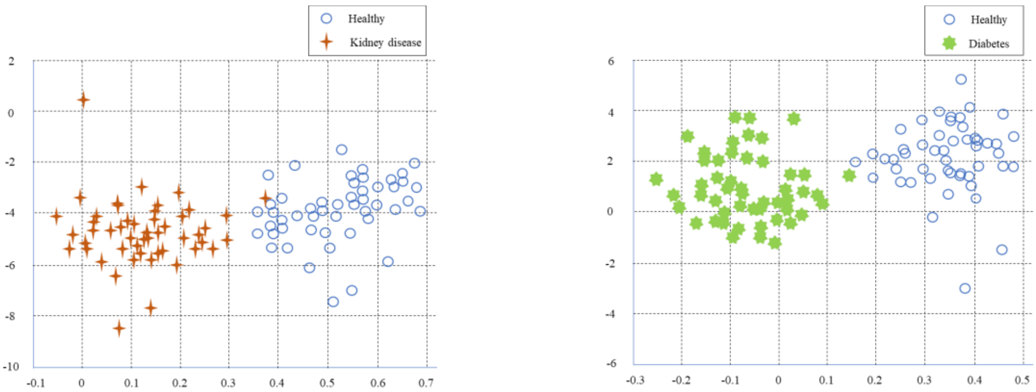
Category	No. of Samples
Healthy Person	50
Kidney disease	50
Diabetes	50

4.2.2 Experimental result



(a) (b)

Figure 8: Disease classification based on Principal Component Analysis



(a) (b)

Figure 9: Disease classification based on Linear Discriminant Analysis

Figure 8 (a) and (b) show the classification of diseases by PCA in comparison of healthy people and nephrotic patients, and healthy people and diabetic patients, respectively. The results show that the samples of healthy people and patients are still mixed together, instead of distinguishing, which may because some high-order components discarded by Principal Component Analysis are the key to distinguish sample data, resulting in unsatisfactory classification result. Figure 9 (a) and (b) show the classification of diseases by Linear Discriminant Analysis in comparison of healthy people and nephrotic patients, and healthy people and diabetic patients, respectively. The results show that the samples of healthy people and patients are well distributed on both sides of the graph, except that one in the nephrotic patients is mixed into the sample of healthy people. Therefore, the performance of Linear Discriminant Analysis is better than that of Principal Component Analysis in classification of diseases associated with oral odors, which can clearly show the dividing line of samples and distinguish healthy people from patients with diseases.

5. Conclusions

Based on the analysis of biological characteristics, this study analyzes the extraction and detection techniques of athletes' oral odors. The specific results are as follows:

(1) This study simply introduces the technique of biological characteristic identification. The uniqueness and stability of human smell lay a foundation for odors as biological characteristics. Several methods of diagnosis and extraction of oral odors are introduced (D'Amelia et al., 2018).

(2) The stability of exhaled gas of individuals is verified by odor chromatography. The results show that the similarity of exhaled gas chromatograms of the three groups for 30 days keeps about 88% on average, indicating that the oral odors of the human body remain stable.

(3) In the electronic nose system, Linear Discriminant Analysis and Principal Component Analysis are used to classify diseases with oral odors. The results show that Linear Discriminant Analysis is superior to Principal Component Analysis in classifying patients with diseases and healthy people.

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