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Analysis of the Effect of Acupressure Point Stimulation on Liver Function Activation through Voice Analysis

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Abstract

This study evaluated the effects of acupressure stimulation on liver function using voice-based acoustic analysis. Specific liver-related acupressure points, including Taechung (LR3) and Ganwha, were stimulated for five minutes in 60 participants (30 males and 30 females). Voice samples were collected before and after stimulation, and two acoustic parameters—the third formant frequency (F3) and the number of voice breaks (NoVB)—were measured. Statistical analysis ($p < 0.05$) revealed significant post-stimulation reductions in both F3 and NoVB, with decreases observed in over 80% of participants. These findings suggest that acupressure may positively influence physiological conditions associated with liver function. Furthermore, the results demonstrate the feasibility of using F3 and NoVB as non-invasive, real-time biomarkers for hepatic function, supporting their potential integration into smart healthcare platforms for continuous monitoring.

Keywords : Acupressure point, Liver function, Third formant frequency, Voice breaks, Voice analysis.

1. Introduction

In modern society, the prevalence and severity of liver diseases have been increasing due to changes in dietary habits, chronic stress, and alcohol consumption. Chronic conditions such as obesity and diabetes—often linked to these lifestyle factors—further contribute to liver dysfunction. This societal shift is expected to continue raising the incidence of liver-related disorders. Globally, liver disease ranks among the top three causes of death—excluding cancer—in individuals aged 30 to 50. Moreover, liver cancer is one of the three most common cancers worldwide, alongside gastric and lung cancer, with minimal differences in incidence rates across regions [1][2].

In traditional Oriental medicine, the liver is regarded as one of the most vital organs, comparable in importance to the heart, and is understood somewhat differently from the perspective of Western medicine. The liver is believed to generate blood, while the heart is responsible for circulating it throughout the body. If inflammation in the liver is detected at an early stage, effective treatment is often possible. However, prolonged undiagnosed inflammation may result in irreversible liver damage. In severe cases where the affected area is extensive, liver transplantation becomes necessary, and failure to treat such conditions can lead to fatal outcomes. Given the liver's essential functions—including metabolism, detoxification, and blood regulation—its impairment can lead to a wide range of clinical complications. Liver diseases encompass a spectrum from mild, asymptomatic conditions to serious illnesses such as chronic hepatitis and cirrhosis [3–5]. Chronic liver disease is a major risk factor for liver cancer, with symptoms often emerging only at advanced stages. Even when liver enzyme levels appear normal, dormant viruses may reactivate and accelerate disease progression. Consequently, chronic liver disease requires continuous monitoring and proactive management to prevent progression to cirrhosis or hepatocellular carcinoma.

The primary causes of chronic liver disease include viral hepatitis (hepatitis B and C), alcoholic hepatitis, and non-alcoholic fatty liver disease. Among middle-aged men, particularly those in their 40s and 50s who are active both socially and professionally, liver disease is a leading cause of mortality. Despite the severity of hepatitis B and C, public awareness remains low, impeding early diagnosis and treatment. To address this issue, the World Health Organization (WHO) promotes global initiatives aimed at eliminating hepatitis at the national level. The Asia-Pacific region bears the greatest global burden, accounting for approximately 70% of deaths related to viral hepatitis. Therefore, the proactive prevention and treatment of viral, alcoholic, and fatty liver diseases are essential for improving public health outcomes [6–10].

In modern healthcare, the emphasis is shifting beyond diagnosis and treatment toward prevention, early detection, and comprehensive health management. Promoting proactive health practices in daily life is becoming increasingly important for improving overall well-being. Simultaneously, the IT convergence industry—which integrates networking, artificial intelligence, and embedded systems—has emerged as a key area of innovation. The convergence of information technology and healthcare is accelerating rapidly, particularly in developed countries, where medical IT is being positioned as a driver of nextgeneration health services. As a result, strategic roadmaps are being established to develop integrated medical IT infrastructures that enable high-value, technology-driven advancements in the healthcare sector [11][12].

Against this backdrop, the present study investigates the effects of acupressure—a traditional complementary medicine technique—on liver function. Specifically, we analyzed voice data before and after stimulation of acupressure points associated with liver function to observe physiological changes. Acoustic features, including voice parameters related to liver function, were extracted from voice recordings collected pre- and post-stimulation, with an emphasis on phonation characteristics affected by hepatic activity.

This study not only explores the physiological responses induced by traditional interventions such as acupressure, but also contributes to the field of health informatics by integrating non-invasive voice analysis into liver function assessment. As the global prevalence of chronic liver disease continues to rise—especially in Asia-Pacific countries—there is a critical need for accessible and cost-effective monitoring tools. Leveraging voice as a diagnostic indicator offers potential for real-time, scalable health assessments aligned with emerging smart healthcare systems.

2. Liver and Acupressure Point

The liver is a large glandular organ connected to the digestive system and is anatomically composed of hepatic lobules, each consisting of hepatocytes. It contains approximately 200 to 250 billion liver cells and carries out a broad range of physiological functions. Anatomically, the liver is located in the right upper quadrant of the abdomen, beneath the diaphragm, and is partially protected by the rib cage. It is encapsulated by a fibrous membrane and presents a glossy, reddish-brown appearance [12–14].

Functionally, the liver plays a pivotal role in metabolism, detoxification, hematopoiesis, bile secretion, and circulatory regulation. It receives a dual blood supply: oxygenated blood from the hepatic artery and nutrient-rich blood from the portal vein, which transports substances absorbed from the gastrointestinal tract. The liver's primary functions include carbohydrate, amino acid, and lipid metabolism; bile acid and bilirubin processing; storage of vitamins and minerals; hormone regulation; and detoxification. Accordingly, liver dysfunction can result in a wide range of systemic clinical complications [14–15].

Common liver disorders include hepatitis, cirrhosis, and fatty liver disease, often caused by alcohol consumption, overeating, chronic fatigue, and prolonged stress. Due to the absence of pain receptors in the liver, symptoms frequently appear only at advanced stages of disease. Thus, preventive measures aimed at maintaining liver function are of great importance. One such approach is acupressure therapy, particularly stimulation of specific points on the back, which is traditionally believed to enhance liver function [16–17].

Back acupressure therapy is designed to promote blood circulation and restore the functional balance of internal organs through targeted point stimulation. It contributes to systemic homeostasis and is widely employed for disease prevention and health maintenance. The therapeutic effects of back acupressure are grounded in several core principles:

First, the principle of nerve reflex: dysfunction in internal organs often manifests as tenderness or muscle hardening at corresponding reflex points on the back.

Second, the principle of circulatory enhancement: the back is located near numerous internal organs, and impaired circulation may result in localized pain. Appropriate stimulation improves the flow of blood, lymph, nutrients, and oxygen.

Third, the principle of energetic balance: according to traditional Eastern medicine, the upper body is associated with yang (active, warm) energy, while the lower body corresponds to yin (passive, cool) energy. An imbalance between these forces is believed to contribute to disease, and stimulation of central back points is used to regulate this energetic harmony [18–20].

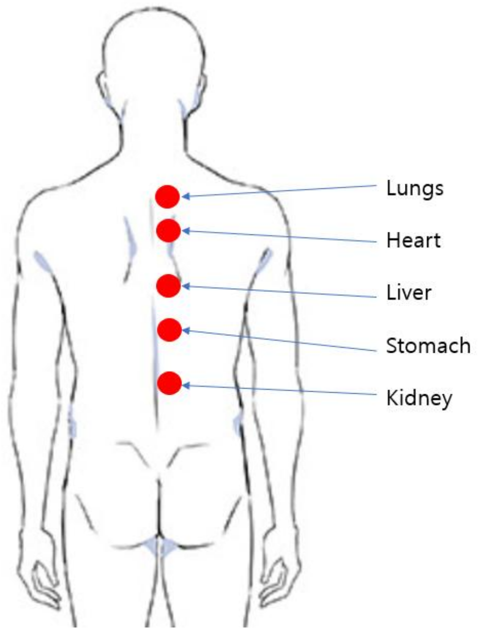

Fig. 1. Back acupressure point corresponding to the organ of the human body

Acupressure point stimulation is reported to have analgesic and stress-relieving effects by regulating the endocrine system. It is non-invasive, has minimal side effects, and offers relatively rapid therapeutic outcomes. By enhancing blood circulation and removing energy blockages, this therapy can normalize the activity of organs and tissues, support chronic disease management, and promote psychological well-being[21–22].

3. Research Process and Methods

In this study, voice analysis was employed as a biometric method that reflects individual physiological characteristics and exhibits minimal temporal variability. To examine the relationship between acupressure stimulation and liver function, voice data were collected and analyzed before and after the application of stimulation to specific acupressure points associated with liver function. The analysis focused on acoustic parameters that are known to be related to liver health.

In particular, changes in the third formant frequency and the number of voice breaks (NoVB) were investigated, as these parameters are considered relevant indicators of vocal resonance and phonatory stability. The dataset consisted of voice recordings from 60 university students in their twenties (30 males and 30 females). The experimental procedure is illustrated in Figure 2.

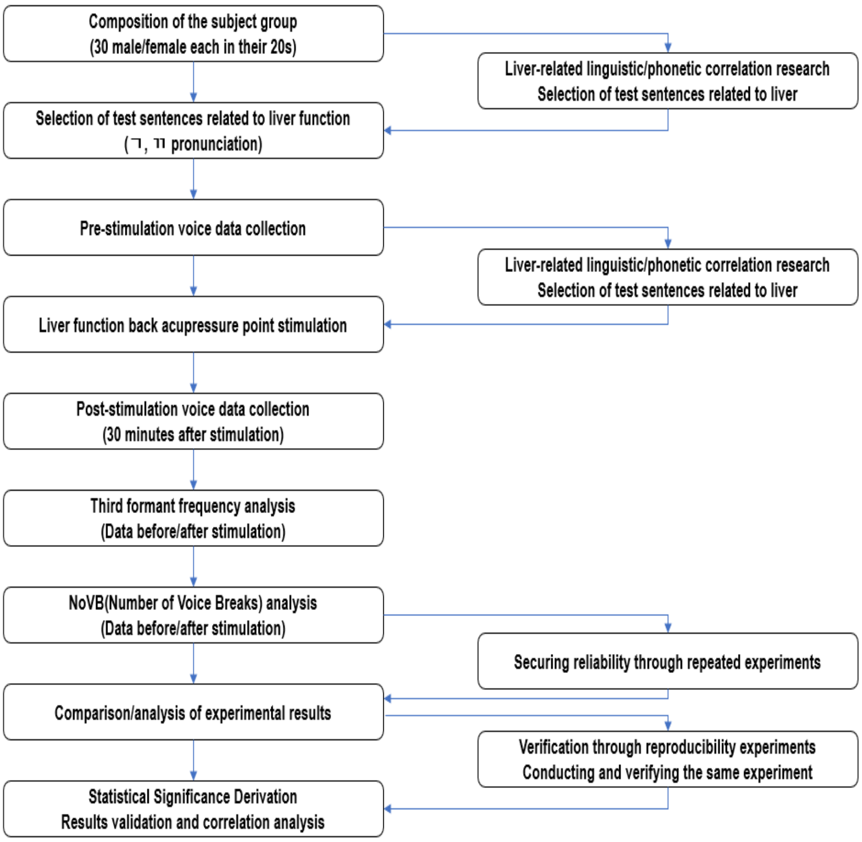

Fig. 2. Research process flow chart

Based on traditional Oriental diagnostic theory, it is hypothesized that impaired liver function may cause articulation difficulties, especially with consonants "ㄱ" and "ㄲ," which are associated with the liver in phonetic organ theory. Therefore, participants were asked to pronounce test sentences rich in those consonants. Voice recordings were conducted under controlled conditions with a 15 cm distance between the subject's mouth and the microphone in a noise-free environment. Each sentence was recorded at least three times within a 10-second duration using a natural speaking voice [23–24].

In addition to the phonetic association, this study aimed to detect measurable changes in resonance and vocalization by analyzing both third formant frequency and NoVB values before and after acupressure stimulation. According to the theoretical framework of traditional Korean medicine, sub-tone sounds associated with liver energy are linked to the third formant frequency. Furthermore, NoVB represents interruptions in vocal continuity, which can reflect tension or instability in voice production. By quantifying these acoustic variables, we aimed to assess physiological changes associated with acupressure.

The theoretical basis for this analysis is rooted in the *auscultation diagnosis* framework of Oriental medicine, which connects the five internal organs with corresponding sounds and phonemes. According to this framework, the liver corresponds to the sounds "ㄱ" and "ㄲ." Thus, speech disturbances in these sounds may indicate dysfunction of the liver[25-27]. Table 1 summarizes this five-element correspondence.

Table 1. Correspondence of five elements, organs, and phonetic representations in Oriental medicine.

Five elements	Wood	Fire	Earth	Metal	Water
Organs	Liver	Heart	Spleen	Lungs	Kidney
Phonemes	ㄱ, ㅋ	ㄴ, ㄷ, ㄹ	ㅇ, ㅎ	ㅅ, ㅈ, ㅊ	ㅁ, ㅂ, ㅍ

In this study, the voice analysis and transformation software Praat was utilized as the primary tool for acoustic signal processing based on the theoretical framework. Voice recordings collected before and after the stimulation of the acupressure point associated with liver function activation were analyzed to examine changes in specific acoustic features. In particular, formant analysis and Number of Voice Breaks (NoVB) analysis were performed.

First, the third formant frequency bandwidth, which reflects changes in the vocal tract, was extracted. This was done by identifying a set number of formants within the designated speech segments and determining the default position values for each formant. For formant extraction, the time step was set to 25% of the analysis window length, allowing fine-grained temporal resolution.

The maximum number of formants was configured to four, with a maximum formant frequency of 4,000 Hz—based on an assumption of approximately 1,000 Hz per formant. The window shape was set to Gaussian, and the analysis was limited to clearly defined voiced speech segments to ensure accuracy.

Pre-emphasis was also applied to enhance the clarity of the formant values. As higher frequencies in speech signals naturally exhibit lower amplitude, pre-emphasis acts as a high-pass filter to amplify those components. In this study, a pre-emphasis frequency of 50 Hz was used, which is known to provide the most accurate extraction of baseline formant frequencies without artificial amplification. For reference, using 100 Hz results in approximately 6 dB amplification, while 200 Hz yields around 12 dB.

Praat applies a Gaussian-like window function for each analysis window and calculates Linear Predictive Coding (LPC) coefficients using the Burg algorithm. The formant frequencies are derived from these LPC values, and both frequency and bandwidth candidates are obtained by computing the roots of the inverse prediction filter A(z).

$$z = e^{sT} \tag{1}$$

$s = -\pi\hat{B} \pm j2\pi\hat{F}$, and $z = R_e(z) \pm jI_m(z)$ is defined as the real and imaginary parts of the complex root. Then, the formant can be obtained as shown in (Equation 2) and the bandwidth can be obtained as shown in (Equation 3).

$$\hat{F} = \left(\frac{f_s}{2\pi}\right) tan^{-1}\left[\frac{I_m(z)}{R_e(z)}\right] \tag{2}$$

$$\hat{B} = -\left(\frac{f_s}{\pi}\right) \ln|z| \tag{3}$$

In addition, the Number of Voice Breaks (NoVB) refers to instances of interruption or pause in vocalization that occur during the articulation of the experimental sentence. It is numerically extracted based on silent segments within the pulse waveform, which are absent when the original voice signal is converted into a pulse representation. Specifically, the minimum pitch was set to 75 Hz, and all pulse intervals were analyzed by segmenting the waveform accordingly. If the interval between two consecutive pulses exceeded 16.6667 milliseconds—

corresponding to the reciprocal of 60 Hz—it was classified as a voice break, and counted toward the NoVB value.

4. Research Results and Analysis

In this paper, we conducted a study to examine changes in liver function following back acupressure point stimulation, as part of preventive approaches related to liver function enhancement. To this end, voice data were collected before and after stimulation of specific acupressure points associated with liver function, and acoustic parameters related to hepatic activity were analyzed. The analysis focused on changes in vocal characteristics that may reflect physiological responses, particularly those linked to liver function.

Two primary acoustic parameters were employed: the third formant frequency bandwidth and the Number of Voice Breaks (NoVB), both of which have been associated with vocal tract stability and phonatory control, respectively.

The experimental environment utilized Microsoft Windows 10 as the operating system. Voice data were recorded using the SONY ICD-SX67, a stereo high-quality (STHQ) voice recorder, to ensure accurate and consistent audio acquisition. For voice analysis, Praat version 6.1.16 was used. Specifically, the built-in modules for Third Formant Bandwidth Analysis and Voice Breaks Analysis were applied to compare pre- and post-stimulation data.

Table 2 presents the results of the third formant frequency bandwidth and NoVB measured before and after back acupressure stimulation for liver function activation in the male subject group. Similarly, Table 3 shows the corresponding results for the female subject group.

Table 2. Results of voice analysis of the male subject group.

Subject	3 formant frequency bandwidth		NoVB(Number of Voice Breaks)	
	Before	After	Before	After
M01	630.846	428.905	10	9
M02	382.694	324.685	12	9
M03	552.850	396.580	10	7
M04	560.995	514.884	9	11
M05	624.854	397.685	12	11
M06	286.365	224.580	11	9
M07	592.054	653.697	8	8
M08	685.620	408.527	12	10
M09	395.651	335.482	10	9
M10	425.685	386.120	10	9
M11	669.482	492.742	13	12
M12	704.586	582.044	10	9
M13	98.857	84.502	9	7
M14	632.810	428.952	12	10
M15	385.642	477.528	9	8
M16	559.640	482.694	10	9
M17	286.945	225.004	11	9
M18	524.918	299.847	13	12
M19	614.590	547.968	10	11
M20	428.458	326.508	11	10
M21	258.961	305.247	8	8
M22	394.582	385.042	14	11
M23	705.127	658.427	11	10
M24	185.670	150.623	9	8
M25	558.637	394.255	9	7
M26	459.621	362.415	10	9
M27	296.505	345.605	8	7
M28	492.680	405.285	11	8
M29	524.684	449.584	7	6
M30	198.474	175.206	12	9

Table 3. Results of voice analysis of the female subject group.

Subject	3 formant frequency bandwidth		NoVB(Number of Voice Breaks)	
	Before	After	Before	After
F01	286.348	180.592	12	9
F02	125.851	185.254	9	9
F03	352.842	240.562	14	10
F04	256.845	238.952	15	12
F05	428.658	286.650	10	9
F06	295.685	277.048	12	13
F07	342.154	295.648	14	11
F08	224.580	220.385	12	10
F09	365.294	335.140	14	13
F10	204.658	174.034	12	10
F11	651.394	394.608	11	8
F12	129.584	184.520	15	12
F13	287.505	285.425	9	11
F14	336.405	188.694	11	10
F15	402.581	265.366	10	8
F16	158.594	142.082	14	11
F17	294.685	265.208	12	9
F18	592.483	338.551	12	10
F19	195.684	269.542	10	9
F20	170.528	164.051	11	8
F21	226.942	184.034	14	12
F22	246.844	204.458	16	13
F23	605.207	394.852	11	8
F24	344.251	316.174	9	10
F25	224.895	299.680	10	9
F26	238.541	189.652	10	8
F27	624.521	487.526	11	9
F28	385.214	335.485	15	11
F29	174.265	296.450	10	8
F30	220.495	214.256	11	9

Tables 2 and 3 present the results of the acupressure point stimulation experiments for liver function activation in the male and female subject groups. In the male group, a decrease in the third formant frequency bandwidth was observed in 26 out of 30 subjects (86.67%), while a decrease in the Number of Voice Breaks (NoVB) was found in 28 out of 30 subjects (93.34%).

Similarly, in the female group, 25 out of 30 subjects (83.34%) showed a decrease in the third formant frequency bandwidth, and 27 out of 30 subjects (90.00%) showed a decrease in NoVB following stimulation.

These findings suggest that back acupressure point stimulation associated with liver function activation may lead to measurable changes in vocal parameters related to resonance and phonation. To further investigate the relationship between these acoustic features and liver function enhancement, statistical analysis was conducted.

The paired t-test was applied to determine the statistical significance of differences in the third formant frequency bandwidth and NoVB values before and after stimulation. This method compares the means of two related samples (i.e., measurements from the same subjects before and after intervention) and is suitable for evaluating the effect of acupressure stimulation within subjects.

Tables 4 and 5 summarize the results of the paired t-test, presenting the mean values, standard deviations, and p-values for the third formant frequency bandwidth and NoVB in the male subject group, measured before and after liver function-related back acupressure stimulation.

Table 4. Statistical analysis results for the 3-formant frequency bandwidth experiment in a group of male subjects

Third Formant Frequency Bandwidth	Stimulation before	Stimulation after
Mean	470.6161	388.3541
Variance	27939.4819196793	18404.5621156104
Observation	30.0	
Pearson correlation	0.8402039509	
t statistic	4.9640057337	
$P(T \leq t)$ one-tail	0.0000140178	
t critical one-tail	1.6991270265	
$P(T \leq t)$ two-tail	0.0000280355	
t critical two-tail	2.0452296421	

Table 5. Statistical analysis results for the NoVB(Number of Voice Breaks) experiment in a group of male subjects

NoVB(Number of Voice Breaks)	Stimulation before	Stimulation after
Mean	10.3667	9.0667
Variance	2.7919540230	2.3402298851
Observation	30.0	
Pearson correlation	0.7455587679	
t statistic	6.1958884708	
$P(T \leq t)$ one-tail	0.0000004660	
t critical one-tail	1.6991270265	
$P(T \leq t)$ two-tail	0.0000009319	
t critical two-tail	2.0452296421	

In addition, Tables 6 and 7 show the sample average value comparison and analysis results for the third formant frequency bandwidth and NoVB for voice before and after liver function activation back acupressure point stimulation in a group of female subjects.

Table 6. Statistical analysis results for the 3-formant frequency bandwidth experiment in a group of female subjects

Third Formant Frequency Bandwidth	Stimulation before	Stimulation after
Mean	313.1178	261.8293
Variance	21121.7744332885	6416.2993599414
Observation	30.0	
Pearson correlation	0.8171500171	
t statistic	3.0447630207	
$P(T \leq t)$ one-tail	0.0024582387	
t critical one-tail	1.6991270265	
$P(T \leq t)$ two-tail	0.0049164775	
t critical two-tail	2.0452296421	

Table 7. Statistical analysis results for the NoVB(Number of Voice Breaks) experiment in a group of female subjects

NoVB(Number of Voice Breaks)	Stimulation before	Stimulation after
Mean	11.8667	9.9667
Variance	4.1195402299	2.5850574713
Observation	30.0	
Pearson correlation	0.7065651298	
t statistic	7.1931461063	
$P(T \leq t)$ one-tail	0.0000000321	
t critical one-tail	1.6991270265	
$P(T \leq t)$ two-tail	0.0000000643	
t critical two-tail	2.0452296421	

Table 4 and Table 5 present the results of the paired t-test for the male subject group. The mean third formant frequency significantly decreased from 470.62 Hz to 388.35 Hz (p = 0.000028, two-tailed), while the Number of Voice Breaks (NoVB) decreased from 10.37 to 9.07 (p = 0.00000093).

Similarly, Table 6 and Table 7 summarize the results for the female subject group. The mean third formant frequency decreased from 313.12 Hz to 261.83 Hz (p = 0.00492), and NoVB decreased from 11.87 to 9.97 (p = 0.00000006).

In both groups, the reductions in third formant frequency and NoVB were statistically significant ($p < 0.05$), indicating that acupressure stimulation had a measurable impact on voice parameters associated with liver function. These findings support the hypothesis that stimulation of liver-related acupressure points contributes to enhanced liver function, which may influence resonance and phonatory stability.

The observed reductions in third formant frequency and NoVB suggest that tension in the vocal tract and irregular phonation patterns may be alleviated following acupressure stimulation. This implies a potential improvement in physiological conditions related to hepatic activity, further reinforcing the relevance of non-invasive voice-based biomarkers in assessing internal organ function.

5. Conclusions

In recent years, the medical paradigm has shifted from a reactive approach centered on diagnosis and treatment to a proactive model emphasizing disease prevention and health promotion. In particular, the convergence of information and communication technologies (ICT) with medicine has driven innovation in personalized healthcare, enabling early detection and continuous monitoring of physiological conditions.

Liver disease—especially those associated with stress, alcohol consumption, and unhealthy lifestyle habits—has emerged as a major public health concern. Consequently, preventive strategies aimed at maintaining and improving liver function are gaining increasing attention. Among these, traditional therapeutic methods such as acupressure have received renewed interest due to their non-invasive nature and demonstrated physiological benefits.

This study examined the effects of back acupressure point stimulation on liver function by analyzing associated changes in voice characteristics. A total of 60 participants (30 males and 30 females) provided voice samples before and after stimulation. Two acoustic parameters—the third formant frequency (F3) and the number of voice breaks (NoVB)—were measured to evaluate changes in vocal resonance and phonatory stability.

The results showed that 86.67% of male and 83.34% of female participants exhibited a decrease in F3 following stimulation, while NoVB decreased in 93.34% of males and 90.00% of females. These reductions were statistically significant ($p < 0.05$), suggesting that acupressure stimulation may positively influence physiological conditions related to liver function.

By integrating traditional Korean medical theories—such as the association between organ health and vocal properties—with modern voice analysis techniques, this study proposes a novel, non-invasive approach for evaluating the effects of therapeutic interventions. The findings highlight the potential of voice-based biomarkers as diagnostic tools for liver function monitoring and point to new research directions at the intersection of bioacoustics and personalized medicine.

Furthermore, this study demonstrates the feasibility of using F3 and NoVB as easily obtainable, real-time indicators of hepatic function, paving the way for innovative health informatics applications in preventive care. Such integration is particularly relevant for smart healthcare platforms that support continuous, at-home monitoring. This approach aligns closely with the focus of *Health* on health informatics and global health promotion. In regions with a high burden of liver disease—such as the Asia-Pacific, which accounts for approximately 70% of global deaths from viral hepatitis—voice-based diagnostic tools can facilitate early screening, self-monitoring, and community-level interventions. In addition, the findings support the potential integration of voice-based metrics into wearable devices and mobile health applications, further reinforcing the role of ICT-driven strategies in preventive medicine and population health management.

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