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Article

Study on the biomechanical effects of magnetic nanomaterials in body injury repair within the context of music intervention

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Abstract: With the progression of science and technology, the application of magnetic nanomaterials in the medical domain has drawn increasing attention. Their remarkable high surface area and biocompatibility endow them with potential in the restoration of body tissues from a biomechanical perspective. This article explores the application of magnetic nanomaterials for the repair of body injuries under the influence of rhythmic music within the framework of biomechanics. The enhanced wavelet threshold denoising algorithm is employed to refine the rhythmic music, aiming to acquire music with better biomechanical-stimulating qualities. The subjects are randomly segregated into four cohorts, namely the control group (Group A), the magnetic nanomaterial group (Group B), the music intervention group (Group C), and the music intervention + magnetic nanomaterial group (Group D). The research findings manifested that, under otherwise identical conditions, the biomechanical recovery time of Group A subjects ranged from 9 to 10 days. For Group B subjects, it was between 7 and 8 days. Group C subjects had a biomechanical recovery time of 8 to 9 days, whereas that of Group D subjects was between 4 and 5 days. The P value among Group A, Group B, and Group C exceeded 0.05. However, the P value between Group D and Groups A, B, and C was less than 0.05, signifying that magnetic nanomaterials could substantially enhance the biomechanical repair efficacy of body injuries when combined with rhythmic music intervention.

Keywords: repair of body injury; magnetic nanomaterials; rhythmic music intervention; wound healing speed; biomechanical effects; inflammatory reaction

1. Introduction

With the continuous development of science and technology, people's research in the field of repair of body injury is also deepening. Traditional repair of body injury methods often requires a long rehabilitation process and has limited effectiveness. However, in recent years, a novel method has attracted widespread attention, which is the application of magnetic nanomaterials in the repair of body injury under the intervention of rhythmic music. Rhythmic music intervention refers to the promotion of the physiological and psychological health of the human body through specific rhythmic, emotional, and structural music stimuli. It has been widely applied in various fields, such as psychotherapy, rehabilitation medicine, etc. Magnetic nanomaterials are a type of material with unique physical and chemical properties, and their applications in the medical field are also receiving increasing attention. In the repair of body injury, magnetic nanomaterials can be used as repair materials to promote the body's self-healing ability through the control and guidance of magnetic fields. These materials have a strong magnetism and can be accurately positioned and manipulated through the action of external magnetic fields, thereby accelerating the repair process of damaged areas. Combining rhythmic music intervention with the characteristics of magnetic nanomaterials, new breakthroughs can be brought to repair body injury.

The repair of body injuries is an important issue facing human health, including fractures, damaged soft tissue repair, etc., so its research has produced many results. Studies by Zhang Wenjuan and others showed that GAH was better than alendronate in repairing bone damage and preventing osteoporosis in zebrafish [1]. The incidence of spinal cord injury (SCI) is increasing. Jing Cong summarized the role of related signaling pathways in treatment, providing a new direction for nerve injury repair [2]. Fang Jie analyzed the literature on finger wound repair for intrinsic digital artery defects and found that perforator flap drainage was the best repair method. However, existing repair methods have long healing processes and high risks of complications. Innovative methods are urgently needed to promote repair [3]. The injury repair methods used in the above studies all have limitations such as long healing processes and high risks of complications. Therefore, it is particularly important to find an innovative method to promote the repair of limb injuries.

Rhythmic music intervention and magnetic nanomaterials, as unconventional treatment methods, have shown remarkable effects in many fields and have received widespread attention in the field of body damage repair. Li Mengxing reviewed the development and application of music therapy in clinical nursing [4], and Duan Deqing reviewed the application of music therapy in pediatric burn pain [5]. Chen Xiaoyong summarized the progress of iron oxide particles in the field of biomedicine and discussed the opportunities of magnetic nanomaterials in magnetic resonance imaging and magnetic thermal therapy of tumors [6]. Kang Jingru introduced the latest research on magnetic nanoparticles in real-time detection, emphasizing their application in protein, nucleic acid, and pathogen detection [7]. The above research lays a solid foundation for combining rhythmic music intervention with magnetic nanomaterials and analyzing its application in body damage repair.

This article comprehensively analyzed the effect of rhythmic music in repairing body injury and the advantages of magnetic nanomaterials in repairing body injury. It introduced in detail the denoising methods of rhythmic music and improved the wavelet threshold denoising algorithm to denoise rhythmic music. The experiment took mice as the experimental objects and randomly divided them into Groups A, B, C, and D. By comparing the wound healing speed, tissue regeneration degree, and inflammatory response of the four experimental groups, it was verified that magnetic nanomaterials under rhythmic music intervention could improve the application effect in repair of body injury. The innovation of this article lay in the discovery that introducing rhythmic music stimulation during the repair process could increase the comfort and effectiveness of treatment, and increase patient engagement and rehabilitation motivation. At the same time, the application of magnetic nanomaterials could achieve precise control of the repair process and improve repair efficiency and quality.

2. Mechanism of the effect of rhythmic music on magnetic nanomaterials in repairing of body injury

2.1. Effect of rhythmic music in repairing of body injury

Rhythmic music, as an art form, has a unique influence and healing effect. In the application of magnetic nanomaterials in the repair of body injury, the role of rhythmic music is mainly reflected in its promotion of physical recovery and repair through intervention mechanisms [8,9].

The rhythm and tone of rhythmic music can stimulate the nervous system of the brain, thereby regulating the physiological functions of the body. This intervention mechanism enables the body to better perceive and respond to treatment stimuli when receiving magnetic nanomaterials, thereby improving treatment effectiveness.

Rhythmic music has a positive emotional regulation effect. The melody and emotional expression of music can affect the emotional state of the audience, thereby affecting the physiological reactions of the body. Positive emotions can promote the function of the body's immune system, and accelerate wound healing and repair of injury processes. Therefore, the intervention of rhythmic music can regulate the emotional state of patients, improve their immune function, and promote the repair effect of magnetic nanomaterials on body damage [10,11].

Rhythmic music can also trigger a relaxation response in the body. The rhythm and sound of music can affect the activities of the autonomic nervous system, thus producing the effect of relaxation and sedation. This intervention mechanism can reduce patients' pain perception, reduce tension and anxiety, and facilitate the development of the body's self-healing ability. In the treatment of magnetic nanomaterials, the relaxation effect of rhythmic music can provide patients with a better treatment environment and experience, enhancing their acceptance and effectiveness of treatment.

The application of rhythmic music intervention in magnetic nanomaterials in the repair of body injury has promoted the recovery and repair of the body through various mechanisms [12,13]. These mechanisms include the neuromodulation, emotion regulation, and relaxation response of music, which together provide useful auxiliary means for the treatment of body injury.

2.2. Advantages of magnetic nanomaterials in repair of body injury

Highly directional navigation: magnetic nanomaterials have magnetic properties and can achieve precise positioning and navigation through external magnetic field control, enabling them to accurately locate damaged areas and improve repair effectiveness.

Improving the therapeutic effect: magnetic nanomaterials can guide the delivery of drugs or biotic components to specific injury areas through the action of the magnetic field, increase the local concentration of therapeutic dose, and improve the therapeutic effect. Magnetic nanomaterials can also assist in image detection and real-time monitoring of therapeutic effects.

Promoting tissue regeneration: magnetic nanomaterials have good biocompatibility and biodegradability, can interact with tissues, and promote cell proliferation and tissue regeneration. By regulating the surface properties and functionalization of magnetic nanomaterials, it is possible to better promote cell adhesion, proliferation, and differentiation, and accelerate the repair of injury process.

Targeted therapy: magnetic nanomaterials can achieve specific targeting through functional modification, selectively act on damaged parts, reduce the impact on healthy tissues, and improve the therapeutic effect. At the same time, magnetic nanomaterials can also be controlled by magnetic fields to control the release speed and position, achieving precise therapeutic regulation.

Improving biocompatibility: magnetic nanomaterials can improve their biocompatibility with organisms, reduce immune and toxic reactions, and enhance the biocompatibility and safety of materials through material characteristic regulation and functional modification.

In conclusion, magnetic nanomaterials have unique advantages in repairing body injury, including highly directional navigation, improving therapeutic effect, promoting tissue regeneration, targeted therapy, and improving biocompatibility. These characteristics make magnetic nanomaterials a potential repair material that can provide new solutions for the treatment of repair of body injury [14,15].

Magnetic nanomaterials bring some potential long-term effects and safety issues in medical use. The long-term biocompatibility of magnetic nanomaterials is an important issue, especially the long-term stability and metabolic pathways in the body. Studies have shown that high concentrations of ferrite nanoparticles can cause cytotoxicity and inflammatory responses, especially when they are accumulated in the body for a long time [16,17]. Magnetic nanomaterials can have toxic effects on specific biological systems, such as potential damage to the liver or kidneys [18]. Magnetic nanomaterials cause immune and inflammatory responses in the body, especially in high doses or long-term exposure, which can affect the therapeutic effect and increase the risk to patients [19,20].

2.3. Noise reduction methods for rhythmic music

1) Wavelet threshold denoising analysis

(1) Rhythmic music denoising

The main purpose of denoising in rhythmic music is to reduce or mask the interference of noise on people through the rhythm, melody, and harmony of the music, providing a more pleasant and enjoyable auditory environment. The following are some specific purposes for denoising rhythmic music:

Reducing the psychological and emotional impact of noise: noise is an unwelcome sound that can cause negative emotions such as anxiety, stress, and fatigue. Rhythmic music, through its beautiful melody and rhythm, can stimulate the brain to release neurotransmitters such as dopamine, thereby promoting physical and mental relaxation and pleasure, and reducing negative emotions caused by noise.

Providing a focused environment: noise often distracts people’s attention, affecting work, learning, and creativity. Rhythmic music can attract people’s attention, thus making it easier to concentrate and improving concentration and work efficiency.

Improving sleep quality: noise is one of the common causes of insomnia and decreased sleep quality. Rhythmic music can help people enter deeper sleep states and improve sleep quality by creating a quiet, peaceful, and relaxed environment.

Providing a pleasant auditory experience: noise can cause discomfort to people’s auditory perception, while rhythmic music has a certain aesthetic and artistic quality, which can provide people with a pleasant auditory experience and improve the comfort of the environment. The denoising principle framework of rhythmic music is shown in **Figure 1**:

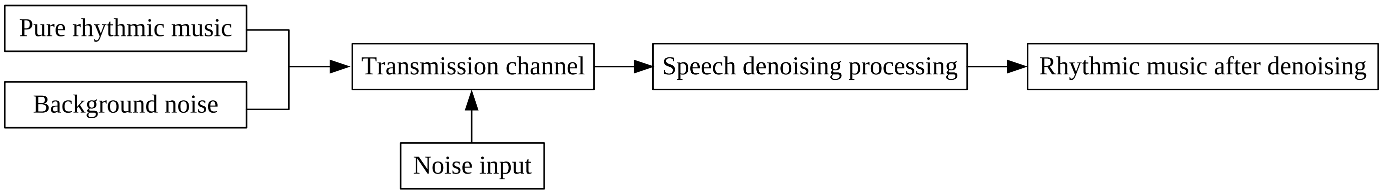

Figure 1. Rhythmic music denoising block diagram.

From **Figure 1**, it can be seen that noise not only exists in the environment of rhythmic music but also generates a type of noise during the propagation of rhythmic music, which is called multiplicative noise, while background noise is an additive noise. By using methods such as homomorphic processing, multiplicative noise can be transformed into additive noise. Therefore, in the denoising of rhythmic music, the main approach is to denoise additive noise.

(2) The basic principle of wavelet threshold denoising method

The wavelet coefficients containing noise components include the wavelet coefficients after converting the original rhythmic music signal and the wavelet coefficients after converting the noise components. Most of the wavelet coefficients in useful signals are located in the low-frequency range, while the noise is located in the high-frequency range, and the wavelet coefficients obtained by the former are much larger than the latter. Therefore, people can set a numerical value so that wavelet coefficients larger than this value remain unchanged, while coefficients smaller than this value are removed. This value is called the threshold. Through quantization operations, the wavelet coefficients are obtained, thereby obtaining the processed wavelet coefficients. Usually, wavelet coefficients below a certain threshold are considered as components of noise, and are removed or given lower weights, while wavelet coefficients above a certain threshold are components of pure rhythmic music, so there is no need to perform calculations or compress them. The core issue of the principle of wavelet threshold enhancement is that the processing method of wavelet coefficients would determine the effectiveness of wavelet threshold enhancement. In this way, the wavelet threshold processing method can be used to reduce the noise component coefficient as much as possible while maintaining the effective signal coefficient, and setting it to zero, thereby achieving effective denoising of the signal. The core of wavelet threshold denoising technology is to select appropriate thresholds and threshold functions, which are directly related to the performance of wavelet threshold denoising. Therefore, in order to achieve the goal of wavelet denoising, it is necessary to select appropriate thresholds and threshold functions. The principle of wavelet threshold denoising is shown in **Figure 2**:

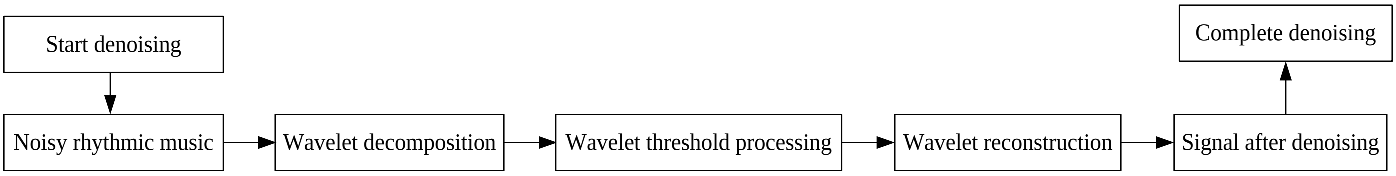

Figure 2. Principle of wavelet threshold denoising.

2) Improved wavelet threshold denoising algorithm

Improved wavelet threshold denoising algorithms can be used to analyze, process, and extract relevant information from rhythmic music. It can obtain key parameters of music by analyzing its rhythm, spectral characteristics, etc. For example, magnetic nanomaterials are used to repair damaged tissues in the body, while being controlled and guided by a magnetic field. In this process, rhythmic music can provide a stimulus signal, and the music feature parameters can be extracted by improving the wavelet threshold denoising analysis of algorithms.

There is a certain relationship between the improved wavelet threshold denoising algorithm and the application of magnetic nanomaterials in the repair of body injury under the intervention of rhythmic music. This relationship is mainly achieved through the rhythm and characteristics of music to control and regulate magnetic nanomaterials [21,22].

Rhythmic music intervention, as a non-pharmacological and non-invasive treatment method, can have a positive impact on the human body through the rhythm, emotions, and structure of music, promoting the body's self-healing ability. In the application of magnetic nanomaterials in the repair of body injury, rhythmic music can be used as a stimulus to regulate and control the behavior and effects of magnetic nanomaterials.

When using wavelet threshold denoising to denoise rhythmic music, there are two commonly used methods: one is the hard threshold function enhancement method, and the other is the soft threshold function enhancement method. In the hard threshold function enhancement algorithm, due to the discontinuity of the hard threshold function, the processed prosodic music may exhibit oscillation, while the prosodic music processed by the soft threshold function denoising algorithm exhibits significant distortion. In response to the shortcomings of the aforementioned wavelet threshold enhancement methods, this article applies an improved wavelet threshold function enhancement algorithm. After the rhythmic music signal is processed through wavelet transform, the obtained wavelet coefficients are thresholded using a new threshold function. This new threshold function algorithm takes into account the exponential decay of modulus in noisy wavelet transforms, rather than setting wavelet coefficients lower than the threshold to 0 directly, as traditional threshold functions do.

(1) Improved threshold function

The common wavelet threshold functions can be represented as follows:

$$\hat{e}_{k,l} = \begin{cases} sgn(e_{k,l})[|e_{k,l}| - (1-x)\varphi] & |e_{k,l}| \geq \varphi \\ x * \dfrac{|e_{k,l}|}{\varphi} * e_{k,l} & |e_{k,l}| < \varphi \end{cases} \tag{1}$$

In Equation (1), $x \in [0,1]$. This threshold function does not directly change the wavelet coefficients below the threshold to 0, ensuring the intelligibility of the speech to a certain extent.

$$\hat{e}_{k,l} = \begin{cases} sgn(e_{k,l}) \left[|e_{k,l}| - \dfrac{\varphi^2}{2|e_{k,l}|} \right] r^{2(\varphi - |e_{k,l}|)} & |e_{k,l}| \geq \varphi \\ sgn(e_{k,l}) \left(\dfrac{\varphi(r^{2|e_{k,l}|} - r^{8q})}{2(r^{8\varphi} - r^{8q})} \right) & |e_{k,l}| < \varphi \end{cases} \tag{2}$$

In Equation (2), $q \in [0,1]$. This threshold function takes into account the clear and turbid sound quality in the speech signal and does not change the wavelet coefficients below the threshold to 0, thus improving the readability of rhythmic music. However, this threshold function remains unchanged near the threshold, and its impact on the denoising of rhythmic music would weaken as the input noise changes.

The soft and hard threshold function is an odd function. Based on the ideas of Equations (1) and (2), this article applies a new threshold function algorithm. The proposed threshold function is not only continuous at the threshold but can also adjust parameters, thus making it more suitable for different noise intensities and further reducing the coefficient of the noise signal and greatly improving the denoising effect. The new wavelet threshold function is also continuous at the threshold, and the function expression is as follows:

$$\hat{e}_{k,l} = \begin{cases} sgn(e_{k,l})\left(\left|e_{k,l}\right| - \dfrac{x\varphi}{r^{\left(\frac{y\left(\left|e_{k,l}\right|^2-\varphi^2\right)}{\varphi^2}\right)}}\right) & \left|e_{k,l}\right| \geq \varphi \\ sgn(e_{k,l})(1-x)\left(\dfrac{\varphi\left(r^{6\left|e_{k,l}\right|} - r^{6q}\right)}{2\left(r^{6\varphi} - r^{6q}\right)}\right) & \left|e_{k,l}\right| < \varphi \end{cases} \tag{3}$$

Among them, y is a positive real number, and $q < \varphi$. When $x = 0$, this function is equivalent to a hard threshold function; when $y = 0$ and $x = 1$, it is equivalent to a soft threshold function.

Continuity:

When the time is $\left|e_{k,l}\right| \to \varphi$ and the domain of a function of threshold function is greater than the threshold, the Equation is as follows:

$$\lim_{e_{k,l} \to \varphi^+} sgn(e_{k,l})\left(\left|e_{k,l}\right| - r^{\left(\frac{y\left(\left|e_{k,l}\right|^2-\varphi^2\right)}{\varphi^2}\right)}\right) = (1-x)\varphi \tag{4}$$

When the time is $\left|e_{k,l}\right| \to \varphi$ and the threshold function domain of a function is less than the threshold, the Equation is as follows:

$$\lim_{e_{k,l} \to \varphi^-} sgn(e_{k,l})(1-x)\left(\frac{\varphi\left(r^{6\left|e_{k,l}\right|} - r^{6q}\right)}{2\left(r^{6\varphi} - r^{6q}\right)}\right) = (1-x)\varphi \tag{5}$$

In Equations (4) and (5), it can be seen that $\lim\limits_{e_{k,l} \to \varphi^+} = \lim\limits_{e_{k,l} \to \varphi^-} = (1-x)\varphi$ and both are equal to a fixed value. This indicates that the new threshold function is continuous at threshold φ. Since it is an odd function, it can be inferred that the function is also continuous at threshold $-\varphi$. In Equation (2), the threshold function is $\pm\varphi/2$ at the threshold, and its estimated wavelet coefficients at threshold φ are constant. However, the value of the new threshold function at threshold φ can be changed because the size of the parameters can be changed.

The asymptote is $\hat{e}_{k,l} = e_{k,l}$.

When $\left|e_{k,l}\right| \geq \varphi$, the improved threshold function can be represented as follows:

$$\hat{e}_{k,l} = sgn(e_{k,l})\left(|e_{k,l}| - \frac{x\varphi}{r^{\left(\frac{y\left(|e_{k,l}|^2 - \varphi^2\right)}{\varphi^2}\right)}}\right) \tag{6}$$

When $e_{k,l} \geq \varphi$, $\hat{e}_{k,l} = \left(e_{k,l} - \frac{x\varphi}{r^{\left(\frac{y\left(|e_{k,l}|^2 - \varphi^2\right)}{\varphi^2}\right)}}\right)$ and the Equation is as follows:

$$\lim_{e_{k,l}\to+\infty} \frac{\hat{e}_{k,l}}{e_{k,l}} = \lim_{e_{k,l}\to+\infty} sgn\left(|e_{k,l}| - \frac{x\varphi}{r^{\left(\frac{y\left(|e_{k,l}|^2 - \varphi^2\right)}{\varphi^2}\right)}}\right) \Big/ e_{k,l} = 1 \tag{7}$$

Since the threshold function is an odd function, $\lim_{e_{k,l}\to-\infty} = \frac{\hat{e}_{k,l}}{e} = 0$. It can be known from the Equations that the asymptote of the new threshold function is $\hat{e}_{k,l} = e_{k,l}$. That is to say, as $e_{k,l}$ increases, $|e_{k,l}|$ approaches $e_{k,l}$, which is not like Equation (1) where there is a certain deviation between the estimated wavelet coefficients and the actual wavelet coefficients.

(2) Threshold selection

When using the wavelet threshold method to denoise rhythmic music signals, the selection of the threshold method has a significant impact on the denoising effect of rhythmic music signals. When the threshold selection is too large, it not only damages the rhythmic music that people want to listen to, but also leads to distortion of the rhythmic music signal. If the selected value is too small, it would result in incomplete noise elimination, making it impossible to achieve the effect of noise elimination.

The common fixed threshold form is $\varphi = \mu\sqrt{2\,ln(M)}$; μ is the standard deviation value in the wavelet coefficients; M is the length of the voice signal. If the wavelet coefficients of each level are ignored and the same threshold is used for wavelet threshold denoising, it is likely to eliminate a considerable number of rhythmic music wavelet coefficients. If appropriate thresholds can be selected for each layer in wavelet decomposition and the wavelet coefficients of each layer can be thresholded, pure speech signals can be retained as much as possible, and the wavelet coefficients of noise can be removed as much as possible, thus achieving good denoising effects. As the scale of wavelet transform increases, the modulus of wavelet coefficients of pure rhythmic music signals after wavelet transform also increases, but the opposite is true for noise components. Therefore, as the scale increases, using fixed threshold processing would treat useful rhythmic music components as noise, resulting in a poorer noise reduction effect. Therefore, under fixed threshold conditions, this article chooses the modified threshold form as follows:

$$\mu = \frac{\delta\mu\sqrt{2\,ln(M)}}{ln(k+1)} \tag{8}$$

Among them, δ is a variable parameter, which can be equal to 1 when the noise is considered white noise. k is the number of wavelet decomposition layers. As it continues to increase, the wavelet coefficients of the noise components would decrease, and the threshold would correspondingly decrease. μ is the standard deviation value in the wavelet coefficients. It is generally believed that $\mu_k = Median(e_{k,l})/0.6745$. $e_{k,l}$ is the kth layer wavelet coefficient. In this way, the threshold can be automatically adjusted according to the transformation scale. The selection of threshold is also a factor that cannot be ignored in wavelet threshold denoising. If the threshold is chosen well, the denoising performance of the wavelet threshold can be improved, and the denoising effect would also be better.

3. Experimental investigation on the effect of magnetic nanomaterials on repair of body injury under the intervention of rhythmic music

3.1. Experimental setup

1) Experimental purpose: The purpose is to evaluate the effectiveness of rhythmic music intervention on the application of magnetic nanomaterials in the repair of body injury.
2) Material preparation

Magnetic nanomaterial injection: Developed magnetic nanomaterials are used for injection, and the injection dose and method are determined based on relevant research.

Music intervention: A specific rhythmic piece of music is designed (This can be fast-paced and melodic music) and played at a fixed time every day to experimental animals in the music intervention group and the magnetic nanomaterial + music intervention group.

3) Experimental grouping

There are four groups randomly divided in this article, namely the control group (Group A), magnetic nanomaterials group (Group B), music intervention (Group C), and music intervention + magnetic nanomaterials group (Group D).

4) Experimental steps

Object selection: 40 mice are selected as experimental objects, numbered 1–10, and randomly divided into Groups A, B, C, and D. Their basic situation is shown in **Table 1**:

Table 1. Basic information of mice in each group.

	Average age (days)	**Average weight (g)**
Group A	126	26.4
Group B	124	26.3
Group C	123	26.6
Group D	125	26.2
P-value	> 0.05	> 0.05

From **Table 1**, it can be seen that the average age and weight of the four experimental groups are not significantly different, and the *P*-values are all greater than 0.05, indicating that there is no significant difference between the groups in age and weight and the experiment can continue.

Performing damage: Injuries are caused, such as cutting injuries, in the designated area of mice.

Methods of causing injury to mice include physical injury and chemical injury. This article uses cutting injuries among physical injuries. Compression injury is to place a specific part of the mouse in a special compression device and use controlled pressure and time to cause compression injury to local tissues, which can simulate muscle contusion, compression injury, and other conditions. Cutting injury is to use a sterile scalpel to cut the skin, muscle, or other tissues of the mouse to cause acute injury. Drug-induced injury is the most common chemical injury, which induces local or systemic injury reactions in mice by injecting or locally applying a certain concentration of chemical drugs.

Treatment stage: Corresponding treatment should be carried out according to different groups.

In this experiment, a total of 40 mice were used as experimental objects, divided into four groups (10 mice in each group) to ensure that the sample size was sufficient to provide statistically significant results. An increase in sample size can reduce Type I errors in testing hypotheses and improve the reliability of research results. The sample size of 40 mice can ensure the statistical significance of the experimental results to a certain extent.

Group A: 10 mice were not subjected to any treatment.

Group B: 10 mice in Group B received magnetic nanomaterial repair without rhythmic music intervention.

Group C: 10 mice in Group C did not receive magnetic nanomaterials, but received rhythmic music intervention.

Group D: 10 mice in Group D received magnetic nanomaterials and played rhythmic music during the repair process.

Observation of treatment effect: At a specific time point after injection, all experimental animals in the experimental group were observed and recorded, including indicators such as wound healing speed, tissue regeneration degree, and inflammatory response.

Appropriate technical means, such as magnetic resonance imaging, tissue sectioning staining, etc., are used to objectively evaluate and analyze experimental results.

Data statistics and analysis: The observed data were statistically analyzed to compare the differences between the four experimental groups.

5) Expected results

If rhythmic music intervention has a positive impact on the repair of body damage with magnetic nanomaterials, the music intervention + magnetic nanomaterials group shows better effects in wound healing speed, tissue regeneration degree, and other aspects, with significant differences compared to other groups.

6) Precautions

When conducting experiments, it is necessary to comply with relevant ethical regulations, ensure the welfare and rights of experimental animals, and obtain approval from relevant institutions before conducting experiments. During the experimental process, attention should be paid to implementing scientific and reasonable control group design and data collection to ensure the reliability of the results.

The control measures implemented to consider external variables are as follows.

1) The experiment selects mice of the same strain, the same gender, and similar age to reduce the potential impact of genetic and physiological differences on the results, and ensure that the health status and growth conditions of the mice are consistent, including diet, environmental temperature, etc.
2) The experiment randomly divides the research objects into different treatment groups, which is an important step in reducing experimental errors and biases. Randomization can balance the potential variables, individual differences, physiological status, etc., between the groups, and ensure the internal validity and comparability of the experimental results.
3) The stability and consistency of the laboratory environment in the experiment should be ensured, including the control of factors such as light, noise, and air quality, to reduce the possible impact of these external environmental variables.

The specific experimental process is shown in **Figure 3**:

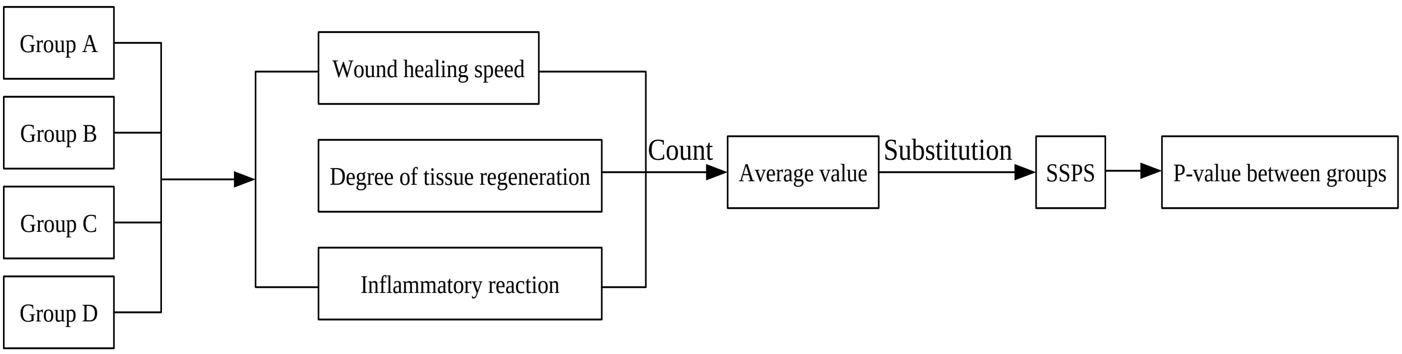

Figure 3. Experimental process of this article.

3.2. Evaluation of experimental results

The speed of wound healing, degree of tissue regeneration, and inflammatory response are important indicators for evaluating the effectiveness of repair of body injury.

1) Wound healing speed

The speed of wound healing refers to the time required from injury to complete healing, which is influenced by various factors, including the type, location, size, depth, individual differences, and treatment methods of the wound. This article would only change the treatment method to ensure that other influencing factors are similar, and record the healing time of each experimental object in the four groups. The results are shown in **Figure 4**:

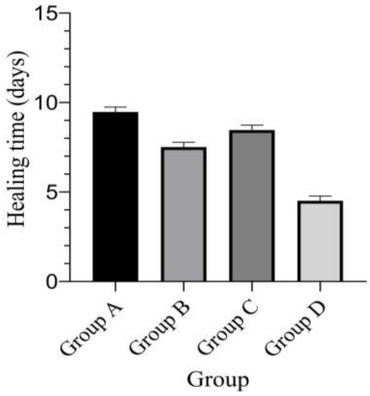

Figure 4. Healing time of four groups of experimental objects.

From **Figure 4**, it can be seen that the healing time of Group A experimental objects was between 9–10 days, while the healing time of Group B experimental objects was between 7–8 days. The healing time of Group C experimental objects was between 8–9 days, while the healing time of Group D experimental objects was between 4–5 days. Compared with Group A, the healing time of Groups B, C, and D decreased, but the healing time of Group D decreased the most, indicating that music intervention could improve the effect of magnetic nanomaterials on the repair of body injury.

According to the data of the four experimental objects in **Figure 4**, the average healing time was calculated and brought into SPSS (Statistical Product and Service Solutions) for the *T*-test. The results are shown in **Table 2**:

Table 2. *P*-values between the average healing time of each group.

	***P*-value**
Group A-B	> 0.05
Group A-C	> 0.05
Group A-D	< 0.05
Group B-C	> 0.05
Group B-D	< 0.05
Group C-D	< 0.05

The *P* value is a measure of how inconsistent the observed data is with the null hypothesis. When the *P* value is less than the significance level (0.05), the observed difference is considered significant, that is, the experiment has sufficient evidence to reject the null hypothesis. On the contrary, when the *P* value is greater than the significance level, the null hypothesis cannot be rejected and the observed difference is considered not significant.

From **Table 2**, it could be seen that the *P*-values between Group A and Groups B and C were all greater than 0.05, and the *P*-values between Groups B and C were also greater than 0.05, indicating that there was no significant relationship between Groups A, B, and C in terms of healing time. However, the *P*-value between Group D and Groups A, B, and C was also less than 0.05, indicating a significant difference in healing time between Group D and the other three groups. This further indicated that music intervention could significantly improve the effect of magnetic nanomaterials on the repair of body injury.

2) Degree of tissue regeneration

The degree of tissue regeneration refers to the ability of a tissue to recover and rebuild after damage or injury, and the cell proliferation rate is an important indicator to evaluate the degree of tissue regeneration. Therefore, this article statistically analyzed the cell proliferation rate of four experimental groups, as shown in **Figure 5**:

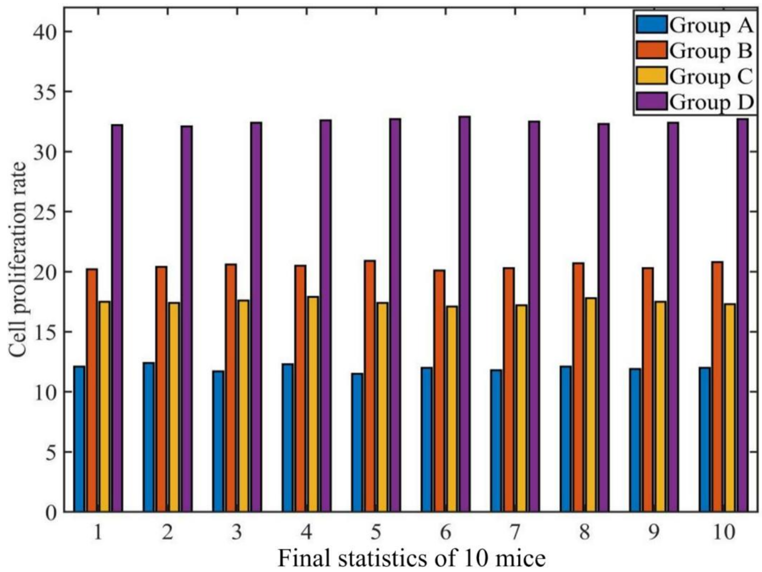

Figure 5. Cell proliferation rate of four experimental objects.

From **Figure 5**, it can be seen that the cell proliferation rate of Group A experimental objects was between 11.4%–12.5%, while the cell proliferation rate of Group B experimental objects was between 20%–21%. The cell proliferation rate of Group C experimental objects was between 17%–18%, while the cell proliferation rate of Group D experimental objects was between 32%–33%. Compared with Group A, the cell proliferation rate of Groups B, C, and D increased, but Group D showed the largest increase, indicating that magnetic nanomaterials under music intervention could improve cell proliferation rate, promote tissue regeneration, and accelerate the body's repair of injury.

According to the data of the four experimental objects in **Figure 5**, the average cell proliferation rate was calculated and brought into SPSS for the T-test. The results are shown in **Table 3**:

Table 3. *P*-values between the average cell proliferation rates of each group.

	***P*-value**
Group A-B	> 0.05
Group A-C	> 0.05
Group A-D	< 0.05
Group B-C	> 0.05
Group B-D	< 0.05
Group C-D	< 0.05

From **Table 3**, it could be seen that the *P* values between Group A and Groups B and C were all greater than 0.05, and the *P* values between Groups B and C were also greater than 0.05, indicating that there was no significant relationship between Groups A, B, and C in terms of cell proliferation rate. However, the *P*-value between Group D and Groups A, B, and C was less than 0.05, indicating a significant difference in cell proliferation rate between Group D and the other three groups. This further indicated that music intervention could significantly enhance the effect of magnetic nanomaterials on the repair of body injury.

3) Inflammatory response

Inflammatory response is a defense mechanism of the body against injury, infection, or stimulation, aimed at protecting tissues from pathogen invasion or other harm. The shorter the time of inflammatory response, the better the effect of repair of body injury. Therefore, this article counted the inflammatory response time of four groups of experimental objects, as shown in **Figure 6**:

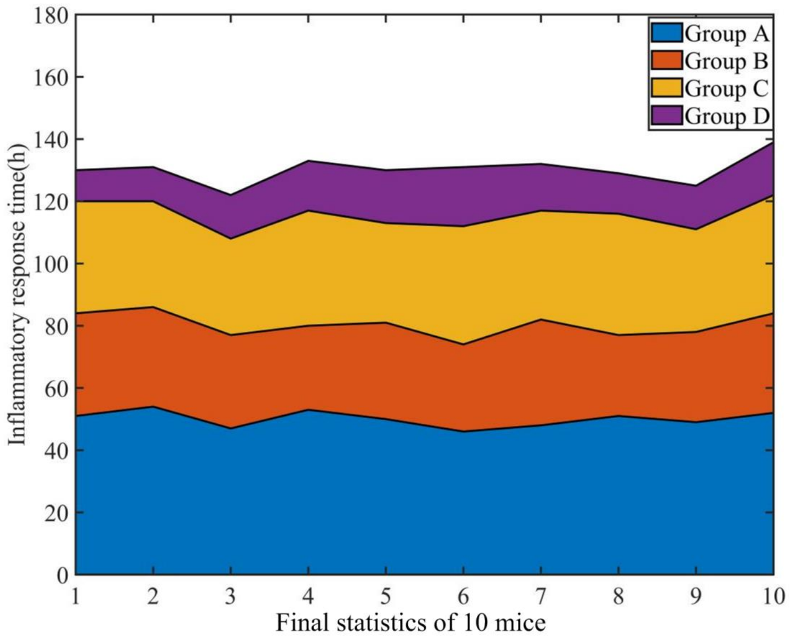

Figure 6. Inflammatory response time of four groups of experimental objects.

From **Figure 6**, it can be seen that the inflammatory response time of Group A experimental objects ranged from 45 h to 55 h, while the inflammatory response time of Group B experimental objects ranged from 25 h to 35 h. The inflammatory response time of Group C objects ranged from 30 h to 40 h, while the inflammatory response time of Group D objects ranged from 10 h to 20 h. Compared with Group A, the inflammatory response time in Groups B, C, and D decreased, but the decrease in Group D was more significant, indicating that magnetic nanomaterials could reduce inflammatory response time under music intervention. This meant that the body could recover to normal faster, which also helped to reduce tissue damage and promote the repair and regeneration of damaged tissues.

According to the data of the four experimental objects in **Figure 6**, the average inflammatory response time was calculated and brought into SSPS for the *T*-test. The results are shown in **Table 4**:

Table 4. *P*-values between the average inflammatory response times of each group.

	***P*-value**
Group A-B	> 0.05
Group A-C	> 0.05
Group A-D	< 0.05
Group B-C	> 0.05
Group B-D	< 0.05
Group C-D	< 0.05

From **Table 4**, it could be seen that the P-values between Groups A, B, and C were all greater than 0.05, indicating that there was no significant relationship between Groups A, B, and C in terms of inflammatory response time. However, the P value between Group D and Groups A, B, and C was less than 0.05, indicating a significant difference in inflammatory response time between Group D and the other three groups. This further indicated that magnetic nanomaterials under music intervention could significantly reduce inflammation response time, which was beneficial for the repair of body damage.

In the inflammatory response, the experiment used ELISA to detect the concentration of inflammatory response proteins, IL-6 and TNF-*α*, which reflects the severity of inflammation. The concentrations of IL-6 and TNF-*α* in each group of mice are shown in **Figure 7**.

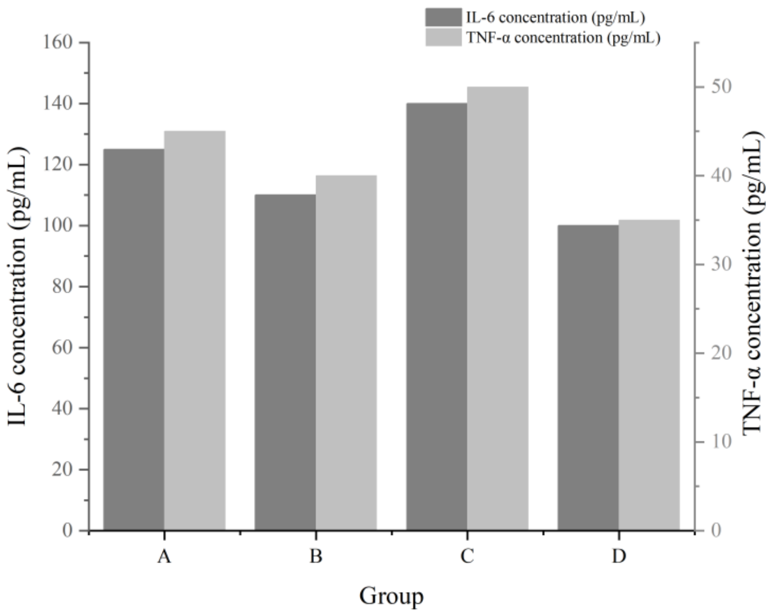

Figure 7. IL-6 and TNF-*α* concentrations in each group of mice.

In **Figure 7**, it can be seen that the IL-6 concentrations in the control group (Group A) and the music intervention group (Group C) are higher, 125pg/mL and 140pg/mL respectively, which shows the inflammation of these two groups of mice. The reaction is more obvious. The concentrations of TNF-α in the control group (Group A) and the music intervention group (Group C) are also higher, 45pg/mL and 50pg/mL respectively, which may also indicate that the inflammatory response in these two groups is more significant.

The concentrations of IL-6 and TNF-*α* in the magnetic nanomaterial group (Group B) and the music intervention + magnetic nanomaterial group (Group D) were relatively low, 110pg/mL and 100pg/mL (IL-6), 40pg/mL and 35pg/mL (TNF-*α*). Among them, the concentration of IL-6 and TNF-α in the music intervention + magnetic nanomaterial group (Group D) was the lowest. It can be seen that the inflammatory response of mice in group D has been suppressed to a certain extent, which is also consistent with the magnetic nanomaterials under music intervention. This can help repair body damage.

4. Conclusions

This article aimed to study the intervention effect of rhythmic music on the application of magnetic nanomaterials in the repair of body injury, and used an improved wavelet threshold denoising algorithm to denoise rhythmic music, thus obtaining pure rhythmic music that could be used for intervention. The experiment involved 40 mice, randomly divided into Groups A, B, C, and D, and compared the wound healing speed, tissue regeneration degree, and inflammatory response of the four experimental groups. At the same time, statistical analysis was conducted on the experimental data, and the P values between the groups were compared through the *T*-test, proving that Group D showed significant improvement in these indicators. This indicated that rhythmic music had a significant intervention effect on magnetic nanomaterials in the repair of body injury. The experimental results would provide a theoretical basis and experimental basis for further improving and promoting the application of magnetic nanomaterials in clinical medicine.

Ethical approval: Not applicable.

Conflict of interest: The author declares no conflict of interest.

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