

Development of Home Beauty Devices for Facial Rejuvenation: Establishment of Efficacy Evaluation System

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Background: Home beauty devices for facial rejuvenation utilizing technologies such as radiofrequency, microcurrent, and light emitting diode have gained widespread attention due to their claimed ability to improve skin tightness and elasticity, making them popular among consumers. However, there is controversy within the industry regarding the effectiveness and safety of these devices.

Objective: This study aims to verify the safety and effectiveness of these home beauty devices in treating skin aging based on relevant efficacy evaluation indicators.

Methods: A systematic search of PubMed and web of science was conducted to include original research literature on the efficacy of home beauty devices for facial rejuvenation over the past two decades. The selected literature was processed and analyzed based on efficacy evaluation indicators such as sample size, follow-up period, experimental results, adverse reactions, and others.

Results: After screening, a total of 18 clinical studies were included. A comprehensive analysis of the experimental results and adverse reaction indicators from existing literature revealed that home beauty devices for facial rejuvenation can improve skin aging to a certain extent. Apart from transient redness and swelling, no other adverse reactions were observed.

Conclusion: Despite the variety of home beauty devices for facial rejuvenation available in the market, corresponding research reports are limited. Existing studies suffer from issues such as small sample sizes and short follow-up periods, highlighting the need for a more comprehensive efficacy evaluation system. Furthermore, the physical stimulation of meridian acupoints by home beauty devices for facial rejuvenation may meet the multi-dimensional anti-aging needs of patients, suggesting a potential direction for future research.

Keywords: facial rejuvenation, home beauty devices, radiofrequency, LED, microcurrent, Meridian acupoints

Introduction

With the increasing aging population and rising consumer demand, there is significant attention on strategies to delay the characteristic signs of skin aging, including sagging, deepening wrinkles, and reduced elasticity.¹ Home anti-aging beauty devices have gained widespread popularity among consumers due to their low cost, convenience, and personalization advantages. These devices utilize technologies such as radiofrequency, LED, and microcurrent to achieve the improvement of skin aging through the effects of light, heat, and electric stimulation on different layers of the skin (Figure 1). However, as these devices are primarily intended for individual or household use and lack professional medical supervision, their energy output levels are lower than those of medical devices.² Consequently, the effectiveness of these devices in effectively improving facial aging is a contentious issue. Furthermore, some news reports have indicated potential risks, such as excessive levels of harmful metal content and the risk of low-temperature burns.^{3,4} Therefore, the safety of these devices must be considered. This paper summarizes and analyzes original research literature related to home radiofrequency, LED, and microcurrent beauty devices for improving skin aging, using efficacy assessment

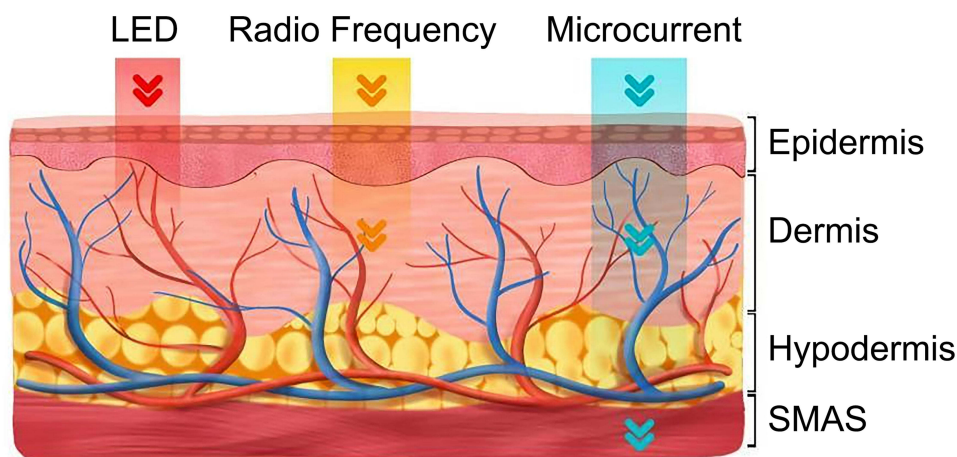


Figure 1 Home beauty devices for facial rejuvenation utilize technologies including radiofrequency (RF), LED, and microcurrent. These technologies provide thermal, light, and electric stimulation to different layers of the skin.

indicators including experimental methods, sample sizes, experimental results, adverse reactions, and others. This analysis aims to validate the effectiveness and safety of home anti-aging beauty devices in improving skin aging.

The Definition of Home Beauty Devices for Facial Rejuvenation

According to “GB/T36419-2018 Household and Similar Use Skin Beautifying Apparatus”, a “home beauty device” is generally designed for the general public to use at home to improve their own skin aesthetics, with a rated voltage not exceeding 250 V for household and similar-use skin beautifying apparatus.⁵ Home beauty devices for facial rejuvenation specifically refer to a category of devices that utilize radiofrequency, laser, phototherapy, and other photoelectric principles to improve skin aging.⁶ As laser-type beauty devices are currently less common and intense pulsed light (IPL) beauty devices fall under medical device regulations, this study focuses only on facial rejuvenation beauty devices primarily employing radiofrequency, LED, and microcurrent technologies.

Technologies Used in Home Beauty Devices for Facial Rejuvenation

Radiofrequency

Radiofrequency delivers high-frequency electric currents to the skin tissue, generating intense heat due to the skin’s impedance.⁷ The localized increase in skin temperature induces changes in the helical structure of collagen in the skin. This, in turn, stimulates fibroblasts to synthesize new collagen and elastic fibers. Heat shock proteins (HSP) such as HSP72, HSP47, transforming growth factor- β , and vascular endothelial growth factor show significant increases after RF treatment, effectively tightening the skin and reducing wrinkles.^{8–10} Given the challenge of controlling the high energy of monopolar RF, home RF beauty devices often use bipolar or multipolar RF, eliminating the need for additional cooling and effectively preventing overheating of the epidermis, reducing the risk of burns during use.¹¹ However, multipolar RF may have a weaker therapeutic effect than monopolar RF due to its shallower energy penetration.⁹ Currently, there is no literature reporting on the application of RF technology to acupuncture points in meridians. In traditional Chinese medicine, moxibustion, a commonly used method, achieves the function of warming and promoting the flow of meridians by locally stimulating acupuncture points with heat, activating specific receptors, heat-sensitive immune responses, and heat shock proteins.¹²

In experimental studies on home beauty devices for facial rejuvenation, four studies employed the TriPollar portable RF beauty device (Table 1). A randomized controlled trial divided skin samples from the neck or abdomen into groups: samples without UV aging and RF treatment, samples with UV aging and no RF treatment, and samples with both UV aging and RF treatment. Histological analysis revealed a significant increase in collagen in the dermal layer of samples treated with TriPollar for 5 minutes compared to the control group ($p < 0.05$).¹³ Another study using TriPollar on 12 subjects for personalized home RF treatments (4–11 sessions) showed regeneration of collagen and metabolic effects on

Table 1 Summary of 9 Clinical Trials on Home Beauty Devices for Facial Rejuvenation Based on Radiofrequency (RF) Technology

Equipment	Empirical Method	Experimental Subject	Experimental Sample Size	Experimental Period	Follow-up Cycle	Experimental Result	Untoward Effect	Patient Evaluation
TriPollar ¹³	RCT	Human skin samples	8	5 min	Not mentioned	The collagen increased significantly in the experimental group after UV aging	Not mentioned	Not mentioned
TriPollar ¹⁴	Non-RCT	Abdomen, face, neck, and arms	12	Personalized treatment 4–11 times according to different sites	Not mentioned	Skin tightening and mean dermal thickness increased after treatment	Transient erythema	Mean satisfaction level 3.75 (5-point assessment)
TriPollar ¹⁵	RCT	Abdominal, leg	24	Treatment is given 2–3 times per week for 12 weeks	Week 6 and 12 week after treatment initiation	Adipocytes appeared with increased collagen, decreased abdominal skin laxity, and decreased thigh dimensions	Not mentioned	The average satisfaction rate was 2.9 (5 Assessment)
TriPollar ¹⁶	Non-RCT	Face	37	8 Treatments	Week 4 and 12 after completion of treatment	Fitzpatrick Blind score, the mean score before and after treatment decreased by 2.42 and 1.55, respectively	Mild transient erythema was noted	89% of subjects reached or to some extent reached the expected values
TriPollar ¹⁷	Non-RCT	Face	23	183 treatments per week	Week 6 and 12 week after treatment initiation	The volume of perioral and periorbital wrinkles decreased by 19% and 41%	Mild transient erythema was noted	Mean satisfaction 3.55 (5-point assessment)
Newa ¹⁸	Non-RCT	Face	45	Week 1–4, 5 times a week	Week 4, 8, and 12 week after treatment initiation	Improved skin tightness and luster (P < 0.05); improved jaw line, skin elasticity, and wrinkles (P > 0.05)	No adverse reactions were seen	Not described
Newa ²⁰	Non-RCT	Face	20	Week 5–12, 2 times a week Once a day for four weeks	Week 2, 4, and 6 week after treatment initiation	There was significant improvement in pigmentation, wrinkles, and no change in melanin and erythema levels	No adverse reactions were seen	Not described
Newa ¹⁹	Non-RCT	Face	62	5 times per week for 4 weeks	Week 4, 8, and 12 week after treatment initiation	Wrinkles improved significantly, and the Fitzpatrick blinded assessment score was statistically significant	Mild transient erythema and redness were noted	Not described
DermaWand ²¹	RCT	Face	50	One treatment	After treatment	The distance from the eyebrow to the hairline decreased by 1.338 ± cm after treatment	No adverse reactions	Not described

fat, achieving skin tightening and body contouring.¹⁴ A randomized controlled trial found that using the home RF device TriPollar improved abdominal and thigh circumference. After the sixth and twelfth weeks of follow-up, adipocyte appearance and collagen increased by 34% and 31%, respectively, and average abdominal laxity decreased from 1.4 to 0.8, with an average reduction of 2.4 cm in thigh circumference without significant weight changes in the subjects.¹⁵ Two additional non-randomized controlled trials using the home RF beauty device TriPollar demonstrated positive effects on facial wrinkles¹⁶ and facial skin firmness.¹⁷ Three studies using the portable RF beauty device Newa in non-randomized controlled experiments for facial aging showed improvement (Table 1). In a study involving 45 participants receiving RF treatment five times a week for the first four weeks and twice a week for the next eight weeks, statistically significant improvements were observed in skin tightness and radiance, with some improvement in jawline, skin elasticity, and wrinkles, though statistically insignificant ($P>0.05$).¹⁸ Another study with 62 participants receiving RF treatment five times a week for four weeks showed significant improvement in facial wrinkles. Blind assessments by three non-participating physicians based on Fitzpatrick scores revealed a significant improvement in facial wrinkles ($P<0.05$). However, a three-month follow-up revealed a decline in facial wrinkle scores after treatment cessation.¹⁹ Results from another Newa study showed improvements in pigmentation, periorbital wrinkles, and facial sagging after treatments twice a week for four weeks. No significant changes were observed in melanin and erythema levels.²⁰ In a randomized controlled trial using the unipolar home RF beauty device DermaWand for eyebrow lifting (Table 1), subjects in the experimental group showed a statistically significant average reduction of 1.338 ± 0.170 cm in the distance from the eyebrows to the hairline after a 3-minute treatment, while the placebo group showed no significant change.²¹ In these studies, some subjects experienced short-lived erythema or swelling after treatment, disappearing within an hour, with no other adverse reactions.

Light Emitting Diode(LED)

The therapeutic potential of light has long been established. Photobiomodulation involves the activation of cellular mitochondrial respiratory pathways, stimulating fibroblast proliferation, collagen synthesis, and the generation of growth factors and extracellular matrix.²² LED photomodulation has been shown to mitigate UVA-induced reactive oxygen species (ROS) and matrix metalloproteinase-1 (MMP-1) expressions through mitochondrial retrograde signaling. This, in turn, enhances antioxidant enzyme expression in a peroxisome proliferators-activated receptor gamma coactivator-1alpha-dependent manner, improving skin aging conditions.²³ In a 10-day study, using 635nm LED light on the acupoints Dazhui and Mingmen of rats with Kidney Yang Deficiency, similar therapeutic effects to moxibustion were observed. This suggests that LED can act on acupuncture points in meridians and have positive effects.²⁴ Since LEDs operate at power levels below what the FDA considers to be medically harmful, they are not subject to the regulations of medical device laws.²

In a clinical study involving a home beauty device combining local serum, LED, and massage (Table 2), subjects experienced a reduction in facial wrinkles, with a significant enhancement in skin density and radiance after continuous treatment for 28 days.²⁵ In a non-randomized controlled trial lasting 8 weeks, the Para. L Dema LED Mask portable LED beauty device (Table 2), combining 637nm and 854nm, was used to treat the left side of the faces of 24 participants twice a week. Results showed that the skin elasticity and moisture on the LED-treated left side were significantly higher than the control group, with improvements in skin texture.²⁶ Additionally, three clinical studies focused on the Omnilux handheld LED beauty device combining 830nm and 633nm red lights (Table 2). In a study where 22 participants alternately received a total of 8 exposures of near-infrared light at 830nm and red light at 633nm over 4 weeks, 74% reported significant improvement in fine lines and wrinkles, 84% reported improved skin tone, and over 70% reported improvements in smoothness and clarity, with 68% reporting improved tightness and 47% reporting enhanced elasticity.²⁷ In a randomized trial where 23 participants received treatment on one-half of their faces using Omnilux, blind photographic assessments showed 59% of patients with clinical improvement, along with changes in skin texture, tone, and fine lines. However, no changes in skin hydration or elasticity were observed.²⁸ After 9 sessions of 20-minute continuous light treatment, 91% of 13 participants with wrinkles or fine lines around the eyes and nasolabial area reported improved skin tone, and 82% reported enhanced smoothness in the treated area. The study suggested better

Table 2 Summary of 4 Clinical Trials on Home Beauty Devices for Facial Rejuvenation Based on LED Technology

Equipment	Empirical Method	Experimental Subject	Experimental Sample Size	Experimental Period	Follow-up Cycle	Experimental Result	Untoward Effect	Patient Evaluation
Para.L Derma LED Mask ²⁶	Non-RCT	Human face	24	Twice a week for 8 weeks	Week 2,4,6, and 8	Skin elasticity and moisture were significantly higher in the LED group than in the control group, and the skin texture was improved	No adverse reactions	Not described
REPAIR ²⁵	Non-RCT	Human face	33	Once a day for 28 days	After 4 weeks	Reduced facial wrinkles and enhanced skin gloss	Mild erythema	Not described
Ommilux ²⁷	Non-RCT	Human face	22	Twice a week for 4 weeks	Week 6,9, and 12	Facial fine lines and wrinkles were significantly improved, and the facial elasticity and tightness were increased	No adverse reactions	Not described
Ommilux ²⁸	Non-RCT	Human face	23	3 times a week for 3 weeks	Week 3,8, and 12	Blind assessment of improved skin texture and fine lines after treatment	No adverse reactions	95% of subjects reported significant skin changes after treatment
Ommilux ²⁹	Non-RCT	Human face	23	A total of 9 times	Week 6,9, and 12	Better skin tone and improved skin smoothness	No adverse reactions	Not described

results in the periorbital region compared to the nasolabial area.²⁹ A few participants experienced transient erythema after the initial use of the device, with no other reported adverse events.

Microcurrent

Microcurrent utilizes low- to medium-frequency pulsed electric currents to generate an electric field as it passes through the skin. This stimulation affects the skin, subcutaneous tissues, and muscles, achieving anti-aging effects such as skin tightening, wrinkle reduction, and improvement of facial contours.³⁰ Low-intensity electrical currents accelerate the repair of connective tissues in the dermis and subdermal layers. Microcurrent stimulation, being compatible with endogenous electrical currents at the cellular level, promotes tissue repair and has positive effects on fibroblast quantity, neovascularization, and epithelial thickness.³¹ Microcurrent stimulation at the Shenmen acupoint can effectively stimulate changes in the activity of the brain's sleep and positive emotion centers.³¹ In a study involving 34 patients with nonspecific chronic neck pain, standardized microcurrent stimulation at back acupoints resulted in an average pain reduction of 80%.³²

Although microcurrent technology has been widely used in home anti-aging beauty devices, there are relatively few research reports specifically focusing on its application in these devices. In a randomized controlled trial using the portable microcurrent beauty device Slendertone Face (Table 3), 56 participants were included in the NMES (neuromuscular electrical stimulation) group, while the remaining 52 participants were placed in the control group. After 12 weeks of treatment, five times a week, participants in the NMES group showed significantly higher facial radiance, skin tone, and reduced wrinkles compared to the control group. Additionally, at weeks 5–6 of treatment, participants in the NMES group exhibited an 18.7% increase in muscle thickness compared to baseline, while the control group showed no significant change.³⁰ A few participants experienced slight skin redness during treatment, with no other reported adverse reactions.

Combination of Multiple Technologies

The combined use of multiple technologies can significantly enhance their effectiveness.³³

In total, we found three clinical trial reports on home beauty devices for facial rejuvenation based on the combination of multiple technologies (Table 4). In an experiment using the TriPollar beauty device combining radiofrequency (1MHz frequency, maximum power of 50W) with dynamic muscle activation (DMA) using microcurrent, 11 participants showed significant improvement in facial skin fine lines, tightness, and brightness after 6 treatments.³⁴ In two studies using home beauty devices combining radiofrequency with LED red light, the YA-MAN device (1MHz RF + 630 nm light source) was used in a randomized controlled trial with 33 participants receiving treatments five times a week for 12 weeks. Blind assessments using a 0–9 scoring system at baseline, second week, fourth week, eighth week, and twelfth week follow-ups showed significant improvement in facial wrinkles and sagging in the experimental group after treatment.³⁵ In another non-randomized controlled trial evaluating the effectiveness and safety of the Silk'n beauty device, 30 participants were assessed using blind Fitzpatrick scores after 21 treatments. The results showed an average decrease of 1.49 points in scores after treatment compared to before treatment.³⁶

Table 3 Summary of 1 Clinical Trial on Home Beauty Devices for Facial Rejuvenation Based on Microcurrent Technology

Equipment	Empirical Method	Experimental Subject	Experimental Sample Size	Experimental Period	Follow-up Cycle	Experimental Result	Untoward Effect	Patient Evaluation
Slendertone Face ³⁰	RCT	Human face	108	5 times per week for 12 weeks	Week 6 and 12	The gloss and wrinkles in the experimental group improved significantly better than that in the control group, and the muscle thickness increased	Mild erythema	Positive effect in 80% of subjects

Table 4 Summary of 3 Clinical Trials on Home Beauty Devices for Facial Rejuvenation Based on the Combination of Multiple Technologies

Equipment	Empirical Method	Experimental Subject	Experimental Sample Size	Experimental Period	Follow-up Cycle	Experimental Result	Untoward Effect	Patient Evaluation
TriPollar ³⁴	Non-RCT	Human face	11	6 treatments	Week 4 and 12	Skin fine lines, firmness, and brightness were significantly improved	No adverse reactions	Not described
YA—MAN ³⁵	RCT	Human face	33	5 times per week for the first 8 weeks 3 times per week for the next 4 weeks	Week 2,4,8 and 12	In the severity of wrinkles (crow's feet, interlines) and facial sagging	No adverse reactions	Not described
Silk 'n ³⁶	Non-RCT	Human face	30	2 days once, a total of 21 times	Week 4 and 8	Fitzpatrick The average reduction of the blind assessment score was 1.49 points	Transient erythema and oedema	Not described

Conclusion

This study summarizes 18 relevant clinical studies on home beauty devices for facial rejuvenation, focusing on evaluation indicators such as whether the experimental methods are randomized controlled trials, experimental sample size, follow-up period, experimental results, adverse reactions, and patient subjective assessments.

Regarding experimental methods, home beauty devices do not necessarily require rigorous double-blind randomized controlled trials, as medical devices do, to validate their effectiveness and safety. While non-randomized controlled trials provide reference values for the efficacy and safety of home beauty devices for facial rejuvenation, their evidence strength may be lower than that of randomized controlled trials. Out of the 18 studies on facial rejuvenation home beauty devices, only five were randomized controlled trials.^{13,15,21,25,35} The sample size directly influences the accuracy and reliability of research results, and some studies suffer from the limitation of having a small sample size, with only three studies^{19,21,30} having a sample size exceeding 50. A short follow-up period cannot verify the sustained efficacy of these devices, and the longest follow-up time in these studies was 12 weeks.^{15–19,27–30,34,35}

The experimental results show that home beauty devices for facial rejuvenation can positively impact various aspects of facial aging, such as wrinkles, facial sagging, skin tightness, and radiance. Test reports^{14,16,17,19,25,30,36} indicate that during the treatment process and subsequent follow-up, subjects experienced only temporary redness and swelling, with no reports of serious adverse events. These experiments were conducted under the supervision of professional dermatologists, allowing for timely intervention and management of any severe incidents. Some reports^{14–17,28,30} also mention subjects' satisfaction with the trial results, scored on a 5-point scale, with satisfaction averaging around 3. Additionally, user experience is crucial for the use of home beauty devices, as a comfortable experience and visible results are essential for user adherence.

However, there are also negative reports about home beauty devices for facial rejuvenation, such as false advertising. Some businesses mislead consumers by suggesting that higher radiofrequency levels yield better results, although there is no supporting evidence. The first generation of Stop Eye home radiofrequency beauty devices by the Initial Pufbrand was recalled due to the potential risk of high temperatures in the device probe leading to low-temperature burns. Improper use of laser or intense pulsed light (IPL) beauty devices can also result in eye injuries.

In conclusion, the limited number of research reports results in insufficient efficacy data, and although dermatologists have released the “Consensus on Selection and Use of Home Anti-Aging Beauty Devices”⁶ to guide consumers in the effective and safe use of these devices, it is still limited due to the diversity of products and a lack of long-term high-frequency clinical studies. Therefore, improving the efficacy evaluation system will help provide a more realistic and effective data foundation for home anti-aging devices. In April 2023, the China National Medical Products Administration released the “Guiding Principles for the Registration Review of Radiofrequency Beauty Devices”, further regulating the management of radiofrequency beauty devices. This indicates that, in the development of home beauty devices for facial rejuvenation, safety standards and supervision standards will become more complete and rigorous.

The theory of meridian acupoints, guided by the holistic principles of traditional Chinese medicine, has the potential to improve and delay the morphological appearance and symptoms manifested in the internal organ systems due to aging. This aims to enhance the aging state and slow down the aging process.³⁷ A study demonstrated that using methods like moxibustion to regulate the immune function of aging mice significantly improved their immune degeneration. This was evident through a marked reduction in serum IL-2 levels and spleen lymphocyte transformation rates, while IL-6 levels increased.³⁸ Acupuncture at Zusanli (ST36) can lower the content of malondialdehyde (MDA) in the skin of aging mice induced by d-galactose, enhance the activity of glutathione peroxidase (GSH-Px), increase hydroxyproline (Hyp) content, improve skin tissue metabolism, raise telomerase activity, reduce epidermal thickness, and suppress the proliferation and inflammatory response of hair follicles and sebaceous glands.^{39,40} According to Chelsea Ma's research, acupuncture can significantly alter facial elasticity, performing well overall in treating conditions such as chloasma and mild pigmentation. Acupuncture is also effective in clearing most acne lesions.⁴¹ Yoshiyama, M found that after facial acupuncture treatment, facial moisture and sebum content increased, and the values of the Facial Check Sheet (FCS) improved.⁴² Thread embedding at facial acupoints can effectively improve facial wrinkles, with fewer side effects and no bleeding or swelling observed.⁴³ By injecting hyaluronic acid at facial acupoints such as Dicang and Cheqiao, it is possible to reduce

blemishes, eliminate facial swelling, achieve a fairer and more radiant complexion, and downgrade the severity of nasolabial groove grading (WSRS) from the third level before treatment to the second level during continuous improvement.⁴⁴ In summary, facial acupoints are distributed abundantly, and by stimulating these acupoints, it is possible to regulate and balance the body's qi and blood, nourish organs, improve bodily functions, and achieve the goal of beauty and anti-aging. With advancing technology, an increasing number of physical stimuli (such as sound, light, and electricity) are being used for acupoint stimulation.⁴⁵ Some research reports^{12,24,31,32} confirm that technologies like microcurrent and phototherapy can effectively act on acupoints. The combination of acupoints with home anti-aging devices can address both external and internal aging, achieving multi-level rejuvenation and becoming a new trend in home anti-aging devices. Currently, there is no research report on the combination of home anti-aging devices and meridian acupoint theory. Further research is needed to explore how to safely and effectively stimulate facial acupoints during the use of home facial anti-aging devices.

Summary

With the development of the beauty industry, home anti-aging beauty devices, as essential tools for skincare, can provide users with more private and effective beauty care services, meeting diverse and personalized needs. In this paper, we have found some evidence for the effectiveness and safety of facial rejuvenation home beauty devices. However, these findings are far from sufficient. Existing studies often employ non-randomized control methods, have small sample sizes, short follow-up periods, incomplete evaluation criteria for results, limited research on subjects' satisfaction with effects and user experience, and other issues. Additionally, most beauty devices in the market only have third-party test reports, but these data are not publicly available. Therefore, it is necessary to establish a comprehensive evaluation system to provide better evidence for their effectiveness and safety.

Acupuncture, as one of the representatives of traditional Chinese medicine, has spread overseas and has successfully become an essential part of Western complementary and alternative medicine. Combining the theory of meridian acupoints with home beauty devices for facial rejuvenation to meet consumers' multi-level anti-aging needs will be our focus in future research.

Ethics Statement

The manuscript does not contain clinical studies or patient data.

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Disclosure

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