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Research Article

Innovation in Laser Epilation: Evaluation of Triple Wave Emission in Super Hair Removal (SHR) and Hair Removal (HR) Combined Protocols

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Abstract

Objective: Evaluate the efficacy and safety of the triple wave laser with cooled tip in a protocol combined with Super Hair Removal (SHR) and Hair Removal (HR), in comparison to traditional protocols of SHR and HR.

Methods: 48 women were divided into three groups: SHR, HR and SHR+HR; with bilateral treatments in the axilla by six sessions with 30-day intervals and a follow up 30 days after the last session. Evaluations included photographic counting of hair, skin temperature, visual scale of pain and patient satisfaction.

Results: All methods showed significant hair reduction and high satisfaction among participants. SHR and SHR+HR methods showed lower pain when compared to HR. Edema and erythema were observed 30 minutes post application for HR and SHR+HR. Axilla temperature showed less variation in the SHR.

Conclusion: The triple wave laser with cooled tip is effective and safe for hair reduction, regardless of the application method.

Keywords: Photoepilation; High-Powered Laser; Triple Wave; Epilation; Hair Removal; Laser Hair Removal

Introduction

Since ancient times, records have existed of the search for hair removal methods. The entry of women into the workforce, coupled with evolving fashion trends, has made hair removal increasingly important. This has led to the development of various methods, ranging from traditional techniques like shaving and waxing to innovative technological solutions. Among these, high-powered lasers have emerged as a popular dermatological tool for epilation [1-3].

The high-powered laser is one of the most widely used tools in dermatology for hair removal. Melanin in the hair shaft absorbs a significant portion of the emitted laser energy, which is then converted to heat. This heat can cause substantial damage to both the hair shaft and follicular stem cells, resulting in hair reduction through the mechanism of selective photothermolysis. This process was first described for the Ruby laser (694 nm), whose wavelength was effective for lighter skin phototypes with dark hair but posed risks for darker skin tones [4,5].

To expand treatment to a broader range of skin types, new laser technologies were developed. The Alexandrite laser (755 nm) has proven safer for lighter to moderately dark skin, while the Diode laser (810 nm) strikes a balance between efficacy and safety across various phototypes [6]. Meanwhile, the Nd:YAG laser (1064 nm) penetrates deeper into the dermis, making it effective for treating deeper hair follicles with minimal risk and it is the preferred choice for skin types IV-VI [7]. Given the advantages of

each wavelength, interest grew in combining the benefits of high melanin absorption (755 nm) with deeper penetration and reduced risk for darker skin tones (810 nm, 1064 nm) [8].

To this method association was given the name triple wave and literature has shown that this technology is safe and effective for the treatment of hair removal in all skin phototypes [9,10]. However, the clinical practice still faces adverse effects, especially in high phototypes. Thus, in order to improve safety of laser hair removal, new equipment was developed where the tip is cooled to remove the excess heat of the adjacent tissues, which are not the target structures. This way, the procedure become more comfortable and help prevent adverse effects that may arise from the most superficial skin layer being exposed to high energy, such as burns, hyperpigmentation or hypopigmentation [11-14].

Furthermore, there are discrepancies both in parameters and application protocols of the triple wave method, given that both quantity and density of hair are factors that may influence the choice of the laser usage method. The Hair Removal (HR) method emits high-energy pulses with short intervals and relatively low repetition rate. The Super Hair Removal (SHR) method, on the other hand, emits a series of low-energy pulses at a high repetition rate. The gradual approach of SHR may provide greater comfort and safety for the individual, especially in sensitive areas and for higher skin phototypes [15-18]. However, to our knowledge there are no studies that compare the HR and SHR application methods, as well as a protocol that combine both methods in triple wave.

Given this context, the hypothesis of this study is that the simultaneous emission of three wavelengths (755 nm, 810 nm and 1064 nm), combined with contact cooling, will be more effective in promoting selective photothermolysis of hair follicles when a treatment protocol starts with high-frequency, low-energy pulses (SHR) for the initial sessions, followed by low-frequency, high-energy pulses (HR) in the later sessions.

This study aims to compare the efficacy and safety of the traditional SHR and HR methods when applied with triple wavelengths, as well as a combined protocol that uses the SHR method for the first three sessions and the HR method for the last three sessions, to achieve optimal selective photothermolysis of hair follicles.

Material and Methods

Type and Location of the Study

This study consists of a randomized, uncontrolled and longitudinal clinical trial, using quantitative and qualitative approaches. It was carried out at the Physiotherapy Clinic of the University Center of Associated Teaching Faculties in Brazil.

Ethical Aspects

The study was approved by the Research Ethics Committee for Human Subjects (registration number 6,775,097). Recruitment of participants took place through social media, where interested individuals received the informed consent form to understand the benefits and risks of the treatment.

Eligibility Criteria

In this study, were included the individuals who agreed in participate and have signed the free and informed consent form, according to the following criteria:

- Female
- Age between 18 and 46 years
- Phototypes from I to V
- Hair present in the axillary region

Were excluded from the study the individuals with the following characteristics:

- Male
- Phototype VI
- Done any other protoepilation technique in the axillary region
- Undergoing hormonal treatment

- Pregnancy and/or lactation
- Using isotretinoin
- Using any photosensitive medication
- Suffering from any photosensitive disease
- Skin lesions such dermatitis and dermatoses, regardless of the body region
- History of cancer in the past 5 years
- Diabetes mellitus and/or decompensated metabolic disorders
- Pacemaker or any other implanted electronic device
- Epilepsy

The adjacent discontinuity criteria were applied:
- Absence of two consecutive session
- Individuals that did not signed the consent form
- Individuals who were exposed to sun or artificial tanning 30 days before or after laser applications

Design of Experimental Groups
After compliance with the inclusion and exclusion criteria, 68 volunteers were randomly distributed in 3 groups that analyzed the application of the laser in both axilla
- Super Hair Removal (SHR) group: 6 sessions of the SHR method, each application was performed using a "scanning" movement over the axilla for 16 seconds, distributed throughout the delimited area
- Hair Removal (HR) group: 6 sessions of the HR method, each application was performed using 21 punctual and single shots, horizontally, distributed throughout the delimited area
- Association of super hair removal + hair removal (SHR + HR) group: SHR method for 3 initial applications followed by the use of the HR method for the last 3 applications, following the executions described in the previous groups

Photoepilation
The epilation procedures utilized the Vega device from IBRAMED®, featuring a 4,000 VA input power, 900 W applicator, 3 cm^2 spot size and three wavelengths (755 nm, 810 nm and 1064 nm). To characterize the simultaneous emission of these wavelengths, the light spectrum was measured using a Monochromator (Bentham IDR300-PSL) in the optics laboratory of Supera - Technology Center.

The SHR application used parameters of 10 Hz emission, 100 ms pulse duration, 10 J/cm^2 energy density, 16-second exposure, applicable to all phototypes and hair densities. For the HR method, phototypes I to III received 2 Hz frequency, 80 ms pulse duration; phototype IV had 2 Hz, 100 ms; and phototype V had 1 Hz, 100 ms. The fluence was determined individually for each volunteer, based on hair density and sensory tolerance. Additionally, for the HR group, the fluence was increased by 1 J/cm^2 with each new session (Table 2).

For the group combining SHR+HR, the protocol for each method was followed: the first 3 sessions used the SHR protocol and the last 3 sessions used the HR protocol, as described in Tables 1 and 2.

The photoepilation protocol consisted of 6 sessions, with 30-day intervals between each session. Before laser application, both the axillae were sanitized with 5% alcoholic chlorhexidine. The treatment area, a 10 x 10 cm^2 square, was then marked on both axillae using a template to ensure precise application.

Phototype	Hair density	Frequency (Hz)	Pulse duration (ms)	Fluence per session (J/cm^2)	Energy per session (J)	Application time (s)
I to V	1, 2, 3	10	100	10	4,700	16

Table 1: Fluence and energy used on the SHR protocol.

Phototype	Frequency (Hz)	Pulse Duration (ms)	Hair Density	Fluence per session (J/cm²)						Energy Per Session (J)						Number of Punctual Shots
				1º	2º	3º	4º	5º	6º	1º	2º	3º	4º	5º	6º	
I	2	80	1	17	18	19	20	21	22	51	54	57	60	63	66	21, in a 10 cm x 10 cm² area
			2	16	17	18	19	20	21	48	51	54	57	60	63	
			3	14	15	16	17	18	19	42	45	48	51	54	57	
II	2	80	1	16	17	18	19	20	21	48	51	54	57	60	63	21, in a 10 cm x 10 cm² area
			2	14	15	16	17	18	19	42	45	48	51	54	57	
			3	13	14	15	16	17	18	39	42	45	48	51	54	
III	2	80	1	14	15	16	17	18	19	42	45	48	51	54	57	21, in a 10 cm x 10 cm² area
			2	12	13	14	15	16	17	36	39	42	45	48	51	
			3	10	11	12	13	14	15	30	33	36	39	42	45	
IV	2	100	1	7	8	9	10	11	12	21	24	27	30	33	36	21, in a 10 cm x 10 cm² area
			2	6	7	8	9	10	11	18	21	24	27	30	33	
			3	5	6	7	8	9	10	15	18	21	24	27	30	
V	1	100	1	5	6	7	8	9	10	15	18	21	24	27	30	21, in a 10 cm x 10 cm² area
			2	4	5	6	7	8	9	12	15	18	21	24	27	
			3	3.5	4.5	5.5	6.5	7.5	8.5	10.5	13.5	16.5	19.5	22.5	25.5	

Table 2: Fluence and Energy ranges used on the HR protocol.

Evaluations

The participants attended twice a month: one day for evaluation and trichotomy and the following day for the epilation treatment. This protocol was repeated for each session, with a 30-day interval between them. For hair count and satisfaction analysis, the participants were reassessed 30 days after the sixth session.

Anamnesis

Anamnesis was always performed by the same evaluator, which was blinded regarding the treatment protocol. The following information were collected: volunteer age, inspection of axillae, skin phototype and hair density. The skin phototype was determined following the Fitzpatrick Rating. Hair density was categorized based on evaluator previous experience, whose visual analysis indicated the hair thickness: 1 = fine, 2 = medium, 3 = thick.

Hair Count

The patients were comfortably positioned in a supine position, with their arms behind their heads to expose the axillas. Photographic records were taken with a digital camera set on a tripod, 10 centimeters from the axilla, vertically aligned with the volunteers. Images were collected 24 hours before each procedure, capturing pre-treatment photos and followed monthly. A photographic evaluation was also conducted 30 days after the last laser application. For the initial assessment, participants were instructed not to perform hair trichotomy three days prior. For subsequent sessions, the evaluator conducted trichotomy 24 hours before the procedure. The collected images were analyzed using Image J software to quantify hair in the treatment area.

Volunteer Satisfaction

Volunteer satisfaction with hair reduction was assessed using an adapted version of the Global Aesthetic Improvement Scale (GAIS). This evaluation began after the second session and continued until 30 days after the final laser application.

Pain Perception

All volunteers were asked to report their pain perception after each laser application, using the Visual Analogue Scale (VAS). On the VAS, pain is categorized as mild (0 to 2), moderate (3 to 7) and intense (8 to 10).

Procedure Safety

To assess the safety of the procedure, a scale was established for volunteers to report the presence or absence of adverse effects, such as edema, erythema, dryness, tingling, itching, hyperpigmentation, post-inflammatory hypopigmentation and burns. The scale is categorized as follows: 0 = no effects; 1 = minimal effects; 2 = mild; 3 = moderate; and 4 = severe. Reports were collected after each application at intervals of 30 minutes, 1 day, 2 days and 3 days.

Temperature

To assess the surface temperature of the treated tissue, a FLIR-E49001 thermographic camera and a Multilaser Saúde - HC260 infrared consultation were used. Participants rested for 15 minutes in an air-conditioned room at approximately 22 ºC. Temperature measurements were taken before and immediately after each laser application and were repeated for all sessions.

Statistical Analysis

All data obtained in this study were subjected to the Shapiro-Wilk normality test. The data that showed normal distribution, where compared using a two-way ANOVA followed by post hoc Tukey test (hair count; pain perception; satisfaction via GAIS; adverse reactions). For temperature data, the comparison was performed using an one-way ANOVA with post hoc Tukey test. For all tests in this study, the significance level was considered to be $p<0,05$.

Results

Characterization of the Triple Wave Light Spectrum

Figure 1 shows the recorded emissions of the 763 nm, 800 nm and 1064 nm wavelengths from the Vega device. These peaks confirm the spectral regions claimed by the manufacturer, validating the triple-wave technology.

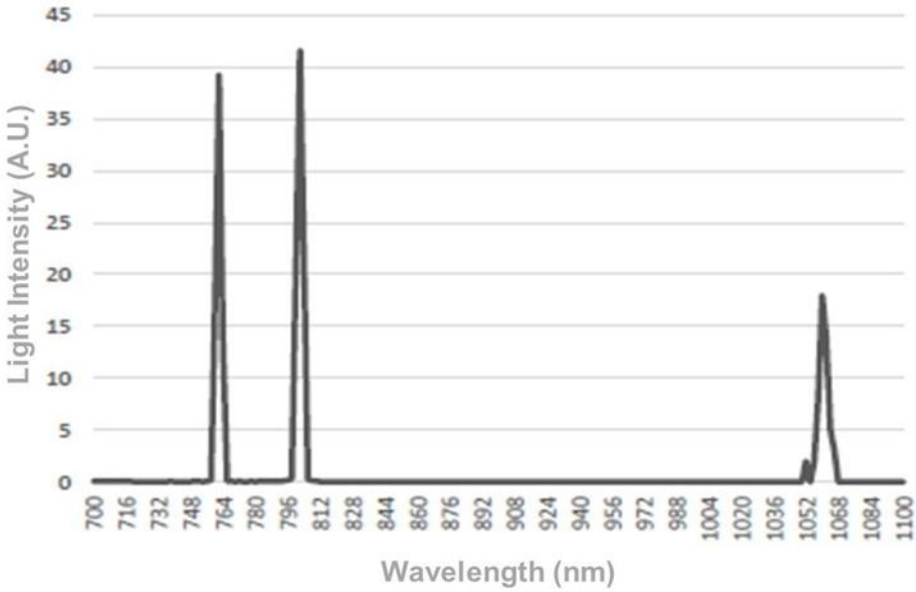

Figure 1: Light spectrum of the Vega equipment.

Sample Specification

Eighty volunteers were recruited for the study, of which 68 met the eligibility criteria and were randomly divided into three experimental groups. During the study period, 20 volunteers were excluded for missing two consecutive sessions. As a result, 48 women completed the procedure.

Regarding the participants' demographic data, the average age was 30 years. The most common skin phototype among the participants was phototype II. In terms of hair density, densities 1 and 2 were predominant in the SHR group, while density 2 was predominant in both the HR and SHR+HR groups. More detailed information about the volunteer profiles is provided in Table 3.

		SHR	HR	SHR + HR
		(N = 16)	(N = 16)	(N = 16)
Age (years)		29 ± 8.7	34 ± 8.7	28 ± 9.0
Phototype	**I**	2 (13%)	0	3 (19%)
	II	7 (44%)	12 (75%)	6 (38%)
	III	5 (31%)	3 (19%)	3 (19%)
	IV	1 (6%)	0	4 (25%)
	V	1 (6%)	1 (6%)	0
Hair density	**1**	8 (50%)	3 (19%)	7 (44%)
	2	8 (50%)	11 (69%)	9 (56%)
	3	0	2 (13%)	0
Source: Author data. (SHR) Super Hair Removal; (HR) Hair Removal; (SHR+HR) super hair removal + hair removal. Mean ± standard deviation. Absolute data and percentages.				

Table 3: Sample profile of the study.

Hair Count

In terms of overall efficacy, all three application methods demonstrated a significant reduction in hair quantity after six laser sessions, with the SHR group showing a 95.59% reduction, the HR group showing a 93.86% reduction and the SHR+HR group showing a 96.60% reduction (Fig. 2). When hair reduction was evaluated across the sessions, a significant decrease in hair quantity was observed up to the third session for all groups. Between sessions 3 and 4 and between sessions 4 and 5, significant reductions were observed for both the SHR and HR groups. However, no significant differences were noted between sessions 5 and 6 for any of the groups.

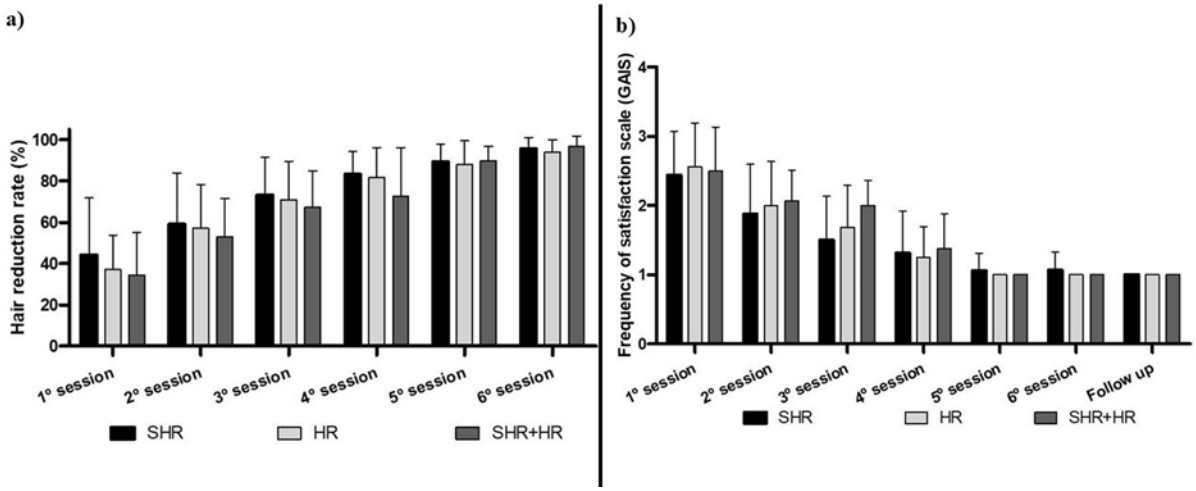

Figure 2: a) Rate of hair reduction; b) Patient satisfaction (GAIS scale). Source: Author data. (SHR) super hair removal; (HR) hair removal; (SHR+HR) super hair removal + hair removal.

Volunteer Satisfaction

Regarding volunteer satisfaction with the treatment, Fig. 2 shows that there were no significant differences in satisfaction levels between the different application methods, indicating that all groups experienced a similar degree of satisfaction with the epilation. However, satisfaction increased progressively across all three groups as the number of sessions increased. Significant differences in satisfaction were observed between sessions 1 and 2 for all groups. Additionally, a significant difference was noted between sessions 5 and 6 for the SHR group and between sessions 3 and 4 for the HR and SHR+HR groups. Notably, volunteers reported maximum satisfaction from session 4 onward in the HR and SHR+HR groups, which was maintained until the end of the treatment.

Pain Perception

Fig. 3 shows the statistical differences in pain levels reported by the volunteers throughout the sessions. The SHR and SHR+HR groups experienced lower pain levels across all sessions compared to the HR group. In session 4, the SHR+HR group reported statistically higher pain levels compared to the SHR group. It is important to note that for the SHR+HR group, session 4 marked the first use of the HR method. When assessing pain levels within each group, it was observed that pain decreased as the number of sessions increased. In the SHR group, although pain levels decreased with each session, a significant difference was observed between sessions 1 and 2 and between sessions 4 and 5. In the HR and SHR+HR groups, pain levels significantly decreased with each session, with notable differences between sessions 1 and 2, 2 and 3, 3 and 4, 4 and 5 and 5 and 6.

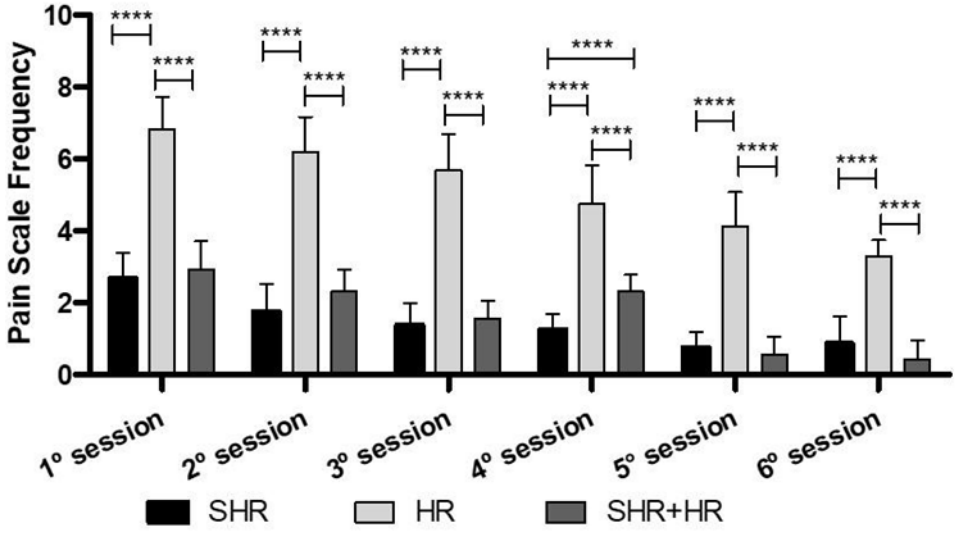

Figure 3: Scale for pain. Source: Author data. (SHR) Super Hair Removal; (HR) Hair Removal; (SHR+HR) super hair removal + hair removal. (****) $p < 0,0001$.

Procedure Safety

Among the adverse reactions evaluated, only erythema and edema were observed, occurring 30 minutes after each application. As shown in Fig. 4, these adverse reactions were reported only in the HR and SHR+HR groups, with statistically significant differences when compared to the SHR group from sessions 1 to 5. When comparing the HR and SHR+HR groups, significant differences were observed in all sessions. During the first three sessions, the SHR+HR group did not report any adverse reactions. However, from session 4 onward, reactions in this group were significantly greater than in the HR group. It's important to note that for the SHR+HR group, adverse reactions were only observed during the sessions in which the HR method was used. In the intragroup analysis, the SHR group did not show any adverse reactions in any session. In contrast, the HR group experienced adverse reactions throughout all sessions, with a gradual decrease over time. However, this decrease was only statistically significant between sessions 2 and 3.

For the SHR+HR group, adverse reactions were observed only during the sessions where the HR method was applied. A statistically significant increase in adverse reactions was noted between sessions 3 and 4. In the following sessions (between sessions 4 and 5 and 5 and 6), a statistically significant decrease in adverse reactions was also observed.

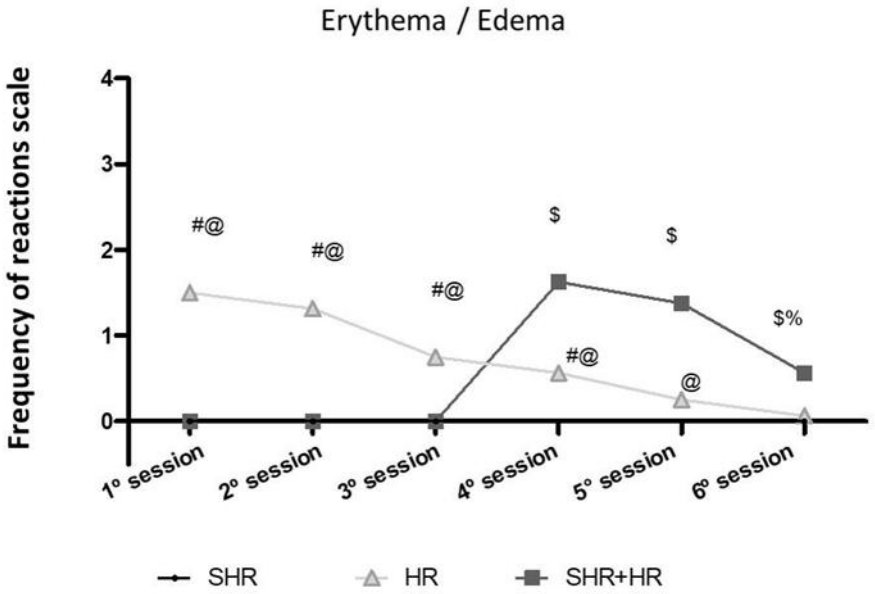

Figure 4: Adverse reactions. Source: Author data. (SHR) Super Hair Removal; (HR) Hair Removal; (SHR+HR) super hair removal + hair removal. (#) SHR vs HR; (@) SHR+HR vs HR; ($) SHR vs SHR+HR.

Temperature

The measurement of axillary temperature after epilation was performed using two equipment: a thermographic camera and a digital thermometer. Both devices showed similar behavior in the variation of axillary temperature. Thus, for both equipment, the SHR group showed smaller temperature variation, with statistically significant difference when compared to the HR and SHR+HR groups. Besides, when comparing the HR and the SHR+HR methods, it was also observed a statistically significant difference with the method SHR+HR showing greater temperature variation (Fig. 5). Regarding the comparison between temperature measurement methods, Table 4 shows the statistical significances. For all groups, the physical evaluation performed with the thermographic camera registered lower temperatures than the ones obtained from the digital thermometer.

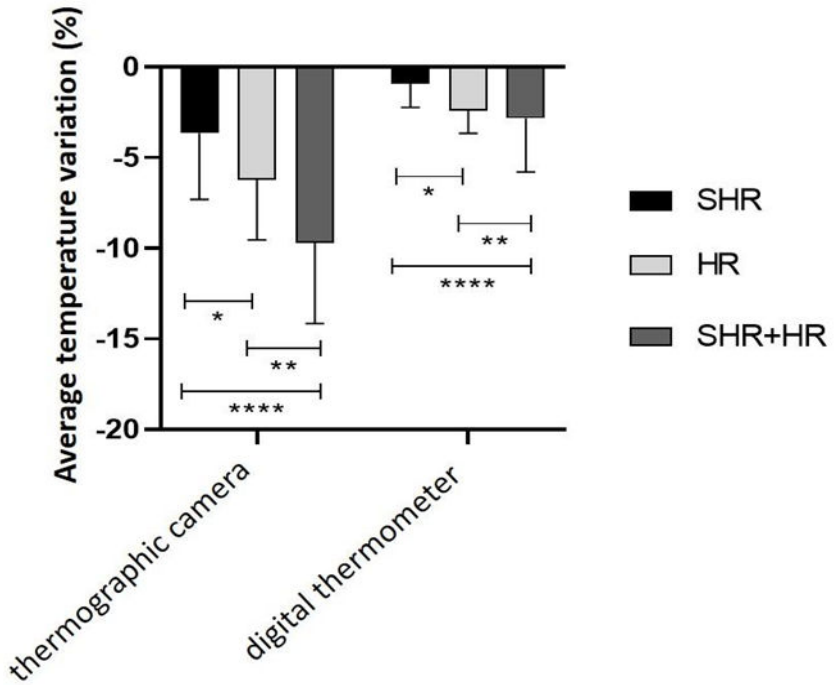

Figure 5: Average temperature variation. Source: Author data. (SHR) Super Hair Removal; (HR) Hair Removal; (SHR+HR) super hair removal + hair removal. (*) $p < 0,001$; (**) $p < 0,01$; (***) $p < 0,0001$.

Method	SHR	HR	SHR+HR
Thermographic Camera	-3.65 ± 3.66***	-6.23 ± 3.32****	-9.72 ± 4.44****
Digital Thermometer	-0.90 ± 1.32	-2.40 ± 1.26	-2.82 ± 2.98
Source: Author data. (SHR) Super Hair Removal; (HR) Hair Removal; (SHR+HR) super hair removal + hair removal. (***) p = 0,0006; (****) p < 0,0001.			

Table 4: Comparison between temperature measuring equipment.

Discussion

Laser hair removal has been established as an effective and safe method, utilizing various wavelengths and technologies to accommodate a wide range of skin phototypes. Among these technologies, the HR and SHR application methodologies stand out, offering advanced options for different treatment needs. However, the benefits depend on several factors, including energy delivery, power settings, pulse duration and frequency. These parameters determine the laser's ability to penetrate the skin and effectively target the hair follicles [10].

To explore these aspects in detail, this study compared traditional SHR and HR methods with a combined protocol that initially applied high-frequency, low-energy pulses (SHR) followed by low-frequency, high-energy pulses (HR) in subsequent sessions. The results showed that the hair reduction rate was not significantly influenced by the energy delivery method, as all groups achieved similar levels of hair growth reduction. Additionally, maximum satisfaction was reported by all participants after six treatment sessions.

Koo, et al., also compared the SHR and HR methods, using only the 810 nm laser [17]. Their findings, which showed similar hair reduction rates for both methods, corroborate the results of this study. However, it is important to note that the wavelength used may also affect hair reduction rates. A meta-analysis of laser hair removal revealed reduction rates of 52.8% for rubi (694 nm), 54.7% for Alexandrite (755 nm), 57.5% for Diode (810 nm) and 42.3% for Nd:YAG (1064 nm) lasers, measured at least six months after the last session [19].

In contrast, the study using the 810 nm laser reported hair reductions of 33.5% for the HR method and 40.7% for the SHR method after six months [17]. The present study, which used the triple-wave (755 nm, 810 nm and 1064 nm) methodology with similar treatment intervals (one session every 30 days), achieved hair reduction rates exceeding 93% for all groups. The triple-wave laser's combination of wavelengths provides a more effective approach in a single session and enhances versatility, accommodating various skin phototypes and hair characteristics [3].

Another factor to consider is the application method's impact on pain levels during the procedure. This study found that the HR method resulted in statistically higher pain levels in all sessions compared to the SHR and SHR+HR groups. Notably, pain perception increased in session 4 for the SHR+HR group, corresponding to the first application of the HR method. Other studies have also reported higher pain levels with the HR method, even for single-wavelength lasers [15,17].

The SHR method offers more comfort during treatment due to its lower energy and higher repetition rate, leading to gradual heating of the treated area. In contrast, the HR method's high-energy, low-repetition-rate pulses result in a concentrated energy application over a short period, making it less comfortable [15]. Regarding adverse effects from high-power laser therapy, literature mentions potential issues such as edema, erythema, dryness, tingling, itching, post-inflammatory hyperpigmentation, hypopigmentation and burns with or without residual blisters [20,21]. In this study, only transient reactions of edema and erythema were observed, lasting approximately 30 minutes and occurring after HR method applications, including in the SHR+HR group. Consequently, discomfort and potential adverse reactions can be minimized by using equipment with a cooling tip [22]. The stable cooling of the epidermis during treatment reduces surface temperature while keeping the internal temperature unchanged [23]. Our study's findings are consistent with this approach, as the integrated cooling tip in the equipment reduced epidermal temperature by up to 16°C. Additionally, the SHR method demonstrated less variation in local temperature. This may be due to the SHR method's continuous energy pulse delivery, which gradually heats the epidermis, resulting in a lower temperature in the skin's superficial layer [18].

The results of this study indicate that the application method did not significantly affect the hair reduction rate but did enhance treatment comfort. Selective photothermolysis was effectively achieved using the pre-programmed protocols of the VEGA equipment. This underscores the ease of use and safety of the technology, with energy parameters tailored to skin phototype and hair density, which are critical for high-power laser use. The study highlights the benefits of detailed protocol calculations and the advantages of adjusting parameters related to frequency and pulse duration. These findings align with the scientific understanding that high-power laser equipment has evolved over time. With a clear understanding of the required parameters, superior therapeutic results can be achieved, enhancing comfort and ensuring the technology's safe application.

Conclusion

The results indicate the efficacy and safety of using the triple-wave laser with a cooled tip for hair reduction, regardless of the application method. Regarding adverse effects, only transient reactions such as edema and erythema were observed, with no severe adverse effects reported in this study.

Conflicts of Interest

The authors declare no conflict of interest in this paper.

Ethical Approval

This study was submitted to the Human Research Ethics Committee, registered under the number 6,775,097. After approval, subject recruitment was carried out through advertisement of social media (Instagram and Facebook). Interested parties were invited to participate in the selection process for the study, in which they received the free and informed consent form (TCLE) in order to understand the benefits and possible risks of the treatment offered in this study.

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Authors' Contributions

All authors contributed to conceptualization, treatment execution, manuscript writing and final approval.

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