The Growth of Human Scalp Hair Mediated by Visible Red Light Laser and LED Sources in Males

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ABSTRACT:

Background and Objective: Low level laser therapy (LLLT) has been used to promote hair growth. A double-blind RCT was undertaken to define the safety and physiologic effects of LLLT on males with androgenic alopecia.

Methods: 44 males (18-48 yo, Fitzpatrick I-IV, Hamilton-Norwood IIa-V) were recruited. A transition zone scalp site was selected; hairs trimmed to 3mm; the area was tattooed and photographed. The laser group received a "TOPHAT655" unit containing 20, 5mW lasers and 31 LEDS, in a bicycle-helmet like apparatus. The placebo group unit appeared identical, containing incandescent red lights. Patients treated at home for QOD x 16 weeks (60 treatments, 655nm, 67.3J/cm^2 irradiance/ 25 minute treatment), with follow up and photography at 16 weeks. A masked 2.85cm^2 photographic area was evaluated by another blinded investigator. The primary endpoint was the percent increase in hair counts from baseline.

Results: 41 patients completed the study. (22 laser, 19 placebo). No adverse events or side effects were reported. Baseline hair counts were 162.7 ± 95.9 (N=22) in placebo and 142.0 ±73.0 (N= 22) and laser groups respectively (P= 0.426). Post Treatment hair counts were 162.4 ± 62.5 (N= 19) and 228.7 ± 102.8 (N= 22) respectively (P=0.0161). A 39% percent hair increase was demonstrated (28.4 ± 46.2 placebo, N=19; 67.2 ± 33.4, laser, N=22) (P=0.001) Deleting one control group subject with a very high baseline count and a very large decrease, resulted in baseline hair counts of 151.1 ±81.0 (N=21) and 142.0 ±73.0 (N=22) respectively (P=0.680). Post treatment hair counts were 158.2 ± 61.5 (N= 18) and 228.7 ±102.8 (N= 22) (P=0.011), resulting in a 35% percent increase in hair growth (32.3 ±44.2, placebo, N=18; 67.2 ±33.4, laser, N=22) (P=0.003)

Conclusions: LLLT of the scalp with the TOPHAT655 device significantly improved hair counts in males with androgenetic alopecia.

ClinicalTrials.gov Identifier: NCT01437163

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Background and Objectives: Low level laser therapy (LLLT) has been used to promote hair growth. A double-blind randomized controlled trial was undertaken to define the safety and physiologic effects of LLLT on males with androgenic alopecia.

Methods: Forty-four males (18–48 yo, Fitzpatrick I–IV, Hamilton–Norwood IIa–V) were recruited. A transition zone scalp site was selected; hairs were trimmed to 3 mm height; the area was tattooed and photographed. The active group received a "TOPHAT655" unit containing 21, 5 mW lasers (655 ± 5 nm), and 30 LEDS (655 ± 20 nm), in a bicycle-helmet like apparatus. The placebo group unit appeared identical, containing incandescent red lights. Patients treated at home every other day $\times$ 16 weeks (60 treatments, 67.3 J/cm^2 irradiance/25 minute treatment), with follow up and photography at 16 weeks. A masked 2.85 cm^2 photographic area was evaluated by another blinded investigator. The primary endpoint was the percent increase in hair counts from baseline.

Results: Forty-one patients completed the study (22 active, 19 placebo). No adverse events or side effects were reported. Baseline hair counts were 162.7 ± 95.9 ($N = 22$) in placebo and 142.0 ± 73.0 ($N = 22$) and active groups respectively ($P = 0.426$). Post Treatment hair counts were 162.4 ± 62.5 ($N = 19$) and 228.7 ± 102.8 ($N = 22$), respectively ($P = 0.0161$). A 39% percent hair increase was demonstrated (28.4 ± 46.2 placebo, $N = 19$; 67.2 ± 33.4, active, $N = 22$) ($P = 0.001$) Deleting one placebo group subject with a very high baseline count and a very large decrease, resulted in baseline hair counts of 151.1 ± 81.0 ($N = 21$) and 142.0 ± 73.0 ($N = 22$), respectively ($P = 0.680$). Post treatment hair counts were 158.2 ± 61.5 ($N = 18$) and 228.7 ± 102.8 ($N = 22$) ($P = 0.011$), resulting in a 35% percent increase in hair growth (32.3 ± 44.2, placebo, $N = 18$; 67.2 ± 33.4, active, $N = 22$) ($P = 0.003$).

Conclusions: LLLT of the scalp at 655 nm significantly improved hair counts in males with androgenetic alopecia. Lasers Surg. Med. 45:487–495, 2013.
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INTRODUCTION

Low-level laser therapy (LLLT) has been studied and used for the treatment of a variety of clinical indications [1–5] including pain management [1,5], wound healing [2–21], and more recently to promote hair regrowth [22–36]. Each of these applications is based on

the principles of photobiomodulation which have demonstrated biological effects in living organisms [1–21].

The potential application of LLLT to stimulate hair growth can be traced to Endre Mester, a physician practicing in Budapest Hungary [22,23]. He discovered that mice treated with lasers during experiments designed to study the potential carcinogenic effects of laser exposure regrew the shaved hair in half the time of non-radiated mice. This 1967 study was the first reference to LLLT and hair growth. Other investigators noted the occurrence of paradoxical hair growth at the periphery of areas treated with lasers for hair removal or adjacent to lesions treated with laser sources [24–26].

These observations led to laboratory and clinical investigations on the effects and applications of LLLT in male and female pattern hair loss [27–36]. The HairMax LaserComb (Lexington International, LLC, Boca Raton, FL) is one such device that has been granted an FDA 510k clearance for use in treating males with Hamilton–Norwood IIa-V and females with Ludwig I-4, II-1, II-2, or frontal patterns of hair loss, in patients with Fitzpatrick I-IV skin types [32,35].

The present study aimed to define the safety and physiologic effects that occur when the human hair follicle and surrounding tissue structures are exposed to LLLT using a novel bicycle helmet type device that is fitted with an array of laser and LED light sources operating at 655 nm. This laser system is classified by the FDA as a class 3R laser, a non-medical laser system (RDW) and therefore, not subject to pre-market clearance or approvals. It may be marketed for hair wellness, which is defined as thicker, denser, more supple, and darker hair shafts. The LED components are non-classified light sources when marketed for cosmetic applications, as is the case here.

MATERIALS AND METHODS

A clinical study was conducted as per the IRB approved TH655 protocol (Essex IRB, Lebanon, NJ; Appendix 1). The trial is registered on www.ClinicalTrials.gov and is assigned the identifier NCT01437163. Forty-four healthy male volunteers 18–48 years old were recruited at two IRB approved treatment sites.

Informed consent was obtained, and the male patients were screened to verify that they met the inclusion and exclusion criteria for the study. History and physical examinations were conducted. All 44 patients had Fitzpatrick skin types I-IV and Hamilton–Norwood IIa-V baldness patterns. An area of scalp was selected in a transition zone at the vertex of the scalp at a site determined by the investigator and based on the individual patient's hair loss pattern. The hairs in the selected site were trimmed to a maximum height of 3 mm in area that was approximately 2.5 cm in diameter. The area was marked with a medical tattoo using green ink using aseptic technique.

The site was then photographed using a custom camera apparatus specifically configured for this purpose. The apparatus consisted of a Canon Rebel T3i 18Megapixel camera system (Canon USA, Melville, NY) equipped with a Tamron 60 mm f/2 Macro lens with 1:1 magnification (Tamron USA, Commack, NY). A 55 mm Lens attachment ring was used to affix a Promaster RL60 LED Ring Light (Promaster, Inc., Fairfield, CT). The camera system was then mounted to a custom Stand-off device which was then manually positioned onto the scalp surface by the investigator each time photographs were taken. Images were taken with the tattoo positioned in the center of the frame. These baseline images were coded and then forwarded to the photographic consultant. The photographic consultant verified that the images were of acceptable quality and processed the images for transmission to the investigator responsible for conducting the hair counts. The transmitted images were masked using a black mask to produce a 1.905 cm diameter circle centered on the tattoo, which provided a consistent 2.85 cm^2 area for hair counts. Neither the photographic consultant nor the investigator performing the hair counts was aware of the identity of the subject or the subjects' study group assignment.

Patients were randomly assigned to active treatment or placebo treatment groups. Each subject received a numbered "TOPHAT655" unit (Apira Science, Inc, Boca Raton, FL) which was distributed to him by the Project Manager, who also provided the patients with instructions for the care and use of the device. Neither the patients, the treating physicians at the clinical sites, the photographic consultant, nor the investigator performing the hair counts was aware whether the device was a therapeutic (active) or a functioning placebo (sham) device. The TOPHAT655 devices used in the study resembled a device currently marketed for home use. However, the investigational devices did not have any corporate logos or other identifiers with the exception of a study investigational device number. (Fig. 1A) serial number was assigned to each helmet, which was then recorded in a device log that contained the code for placebo and actual test unit reference. This log was not revealed to any investigator, subject, office staff, hair counter, or sponsor employee.

The active treatment group received a "TOPHAT655" unit containing 20, 5 mW lasers, and 31 LEDS both operating at 655 nm (655 ± 5 nm and 655 ± 20 nm, respectively) and providing constant illumination over the scalp under the apparatus (Fig. 1). Each subject self-treated at home for 25 minutes/treatment every other day for 16 weeks (60 treatments, 67.3 J/cm^2 delivered irradiance per treatment session).

The placebo or sham group received a unit that was identical in appearance and function to the laser group devices, with the exception that the light sources were incandescent wheat lights that were painted red to mimic the appearance and configuration of the functioning device. Each subject in the sham group self-treated at home for 25 minutes/treatment, every other day for 16 weeks (60 treatments). The interior view of the placebo device is shown in Figure 2. Note that incandescent sources were substituted 1:1 for each laser diode and LED source position on the helmet's interior.

The light output of the active treatment and sham treatment devices was determined using an Ophir Nova Display Power Meter equipped with a Model 30A-P-R-SH

Fig. 1. The TOPHAT655 device unit exterior view. An example of the experimental device is shown with the control unit and power cord attached. Note that there are no identifying markings on the unit with the exception of the device number which is written on the top of the unit.
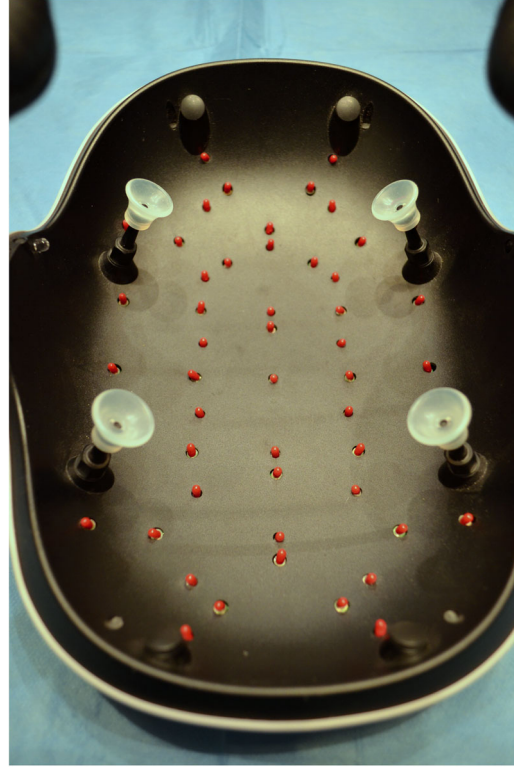

Fig. 2. The interior view of a placebo TOPHAT655 device unit. The interior view of a placebo unit is shown to illustrate the arrangement of the light sources within the unit. Incandescent panel lamps have been substituted for LED and Laser diodes at all light source locations on the helmet interior. Adjustable silicone bumpers allow for customized positioning on the subject's scalp.

detector head (Ophir-Spiricon, LLC, Logan, UT). The active devices delivered an energy density of $67.3\,\text{J/cm}^2$ at 655 nm per 25 minute treatment session at the level of the scalp. The placebo units delivered no measurable light at scalp level. The active device design was such that constant illumination was delivered over the areas of the scalp covered by the device.

The operating temperatures of the active and placebo devices were matched and were measured using a Klein Tools Model IR 3000 Thermometer (Klein Tools, Lincolnshire, IL). The temperature of the units was $27.78 \pm 0.3°C$ at the level of the electronics and $22.22 \pm 0.3°C$ on the interior surface of the helmet.

Study treatments were self-administered as follows: The subject's head was self-positioned within the helmet, until a sensor triggers the start of therapy. There was no contact between the subject and the light-emitting device; only the light reaches the subject scalp. Treatment duration was set to 25 minutes. The lasers and LEDs automatically shut off after the treatment session was complete. All device function was controlled by a hand set that was actuated by the user subject once the power cord was plugged into a standard 120 V outlet and the start button was pressed. All other functions were pre-programmed and automatic. A full set of user instructions

accompanied each helmet. There was no pre or post treatment care required, only that subjects' hair must be clean and not contain spray or gel fixative agents. No safety eyewear was required during the treatment session. A complete demonstration of the proper use of the helmet was provided to each subject at the time the test units were distributed. Periodic subject monitoring was conducted by telephone. Subjects were queried relative to their use of the device and for any possible side effects or adverse events.

The subjects returned at 16 weeks for follow up and post treatment photography of the previously marked area. The area was again trimmed and photographed as per the initial visit. The photography was conducted using the same apparatus and conditions as at baseline. The images were processed, transmitted and analyzed in the same fashion as was the case for the pre-treatment photographs.

One pre-treatment (baseline) and one post-treatment image was counted for each subject. The number of terminal hairs present in the masked area was counted and recorded.

Data analysis was conducted by a consulting statistician, who was provided the raw data and who was blinded as to the identity of the subjects or their individual treatments. The primary endpoint for evaluation was the

percent increase in hair counts from baseline at the end of 16 weeks of treatment. The percent increase from baseline is the obtained by the following formula:

$$X = 100 \times \frac{\text{(End Count} - \text{Baseline Count)}}{\text{Baseline Count}}$$

A data pooling analysis was done to determine whether there was a site by treatment interaction in the percent increase. An analysis of variance was done with only site, treatment group, and site by treatment group interaction in the model and the interaction was not statistically significant. The data were pooled across both sites to arrive at an estimate of the effect for the primary endpoint. Univariate tests comparing the Sham and Active treatment groups were by Wilcoxon rank-sum tests, and an unequal variance t-test was performed.

RESULTS AND STATISTICAL ANALYSIS

Study Site Subject Distribution

The study was a blinded multicenter study. The study subjects were allocated to Laser or Sham on a 1:1 basis at each of two study sites. The distribution of study subjects by random treatment assignment and study site are given in Table 1.

A total of 44 patients were enrolled in the study and completed baseline screening and photography. However, three subjects who were allocated to the sham group failed to return for 16-week evaluation at treatment site 2. Thus there were 22 patients in each group at baseline, but 22 laser and 19 sham patients were available for analysis at the end of the study after 16 weeks of treatment.

There were no reported side effects or adverse events reported by any subject or site at any time during the conduct of the study.

Hair Counts and Photography

Photographs of the selected scalp site were taken prior to any treatment (baseline) and the same site was again photographed after the final treatment had been performed (post-treatment).

Examples of baseline (pre-treatment) and final (post-treatment) images are presented in Figures 3 and 4. Figure 3 demonstrates the results for typical patients in the placebo or sham group. Note that there is minimal change in the 16-week study interval. Figure 4 demonstrates baseline and final images for typical subjects in the

TABLE 1. Subjects, Treatment Assignments, and Study Sites

Site	Sham (placebo)	Active treatment	Total
1	13	13	26
2	9	9	18
Total	22	22	44

The distribution of study subject by treatment site and their assignments are shown.

active treatment group. Note that there is a significant increase in the number of terminal hairs present and that the individual hairs subjectively appear to be thicker and more deeply pigmented than they were at baseline. However, the diameter of the hairs was not measured.

Baseline Hair Counts

The analyses reported below were conducted in Minitab 16 (Minitab, Inc., State College, PA). The raw data for these analyses appear in Appendix 1.

The baseline hair counts by treatment group and study site are presented in Table 2. While the two study sites differ in the absolute values for the mean baseline hair counts, there was no statistical difference between the mean hair counts in the active and sham group subjects at the particular study center. An analysis of variance was done with only site, treatment group, and site by treatment group interaction in the model and the interaction was not statistically significant ($P = 0.094$). The study site was used as a possible covariate in the multivariable analyses performed below.

Primary Analysis

The primary endpoint was the percent increase in hair counts from baseline at the end of 16 weeks of treatment. The percent increase from baseline was obtained for each subject by using the formula above.

A data pooling analysis was done to determine if there was a site by treatment interaction in the percent increase. If the interaction between site and treatment was significant with a $P < 0.15$, there would be evidence of a site by treatment interaction that would require weighting the site results to get an estimate of the study effect. An analysis of variance was done with only site, treatment group, and site by treatment group interaction in the model and the interaction was not statistically significant ($P = 0.349$). Thus the data were pooled across both sites to arrive at an estimate of the effect for the primary endpoint.

Univariate tests comparing the Sham and Active Treatment groups were intended to be by Wilcoxon rank-sum tests unless the variance between the two groups was statistically significantly different. In that case, the comparison was conducted by an unequal variance t-test. The results of the pooled data analysis appear in Table 3.

These results indicate that the univariate result comparing the increase in hair counts was statistically significant ($P = 0.001$). The results indicate that low level laser treatment for 16 weeks increases mean hair counts by about 39%. A multivariable analysis accounting for baseline differences in hair counts by study site indicates that the percent increase by treatment adjusted for study site differences still had a significant effect ($P < 0.0001$). The study site differences in baseline counts did not diminish the effect of treatment on the percent increase in hair counts after treatment. A second supportive multivariable analysis used baseline count as a covariate and in that analysis, the baseline term was significant ($P = 0.035$),

Fig. 3. Pre and post treatment image examples for Sham treatment group subjects. Pre-treatment and 16 weeks post-treatment photo pairs are shown for two placebo group subjects. Hair counts were 102 at baseline and 109 at 16 weeks in subject 83 (**A**) and 65 and 80, respectively in subject 93 (**B**).

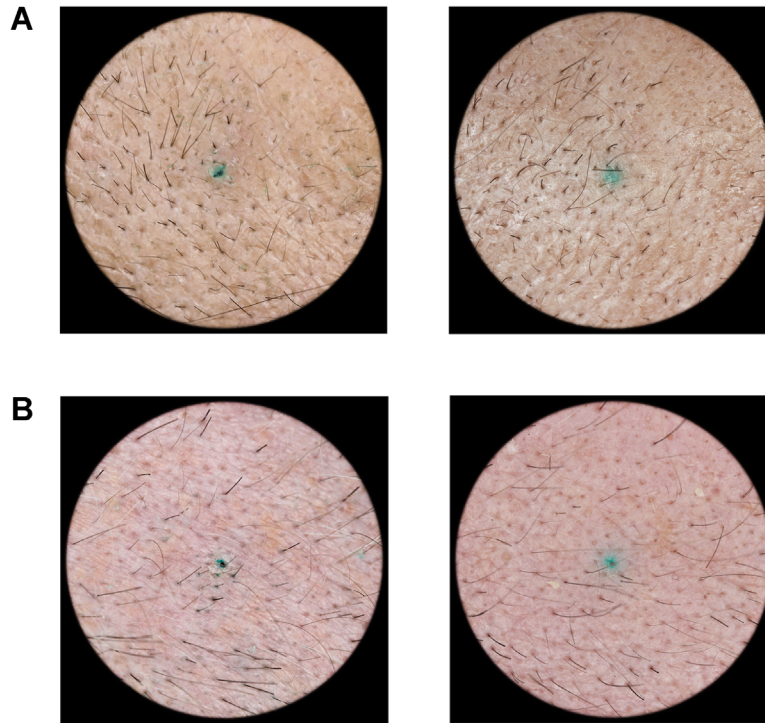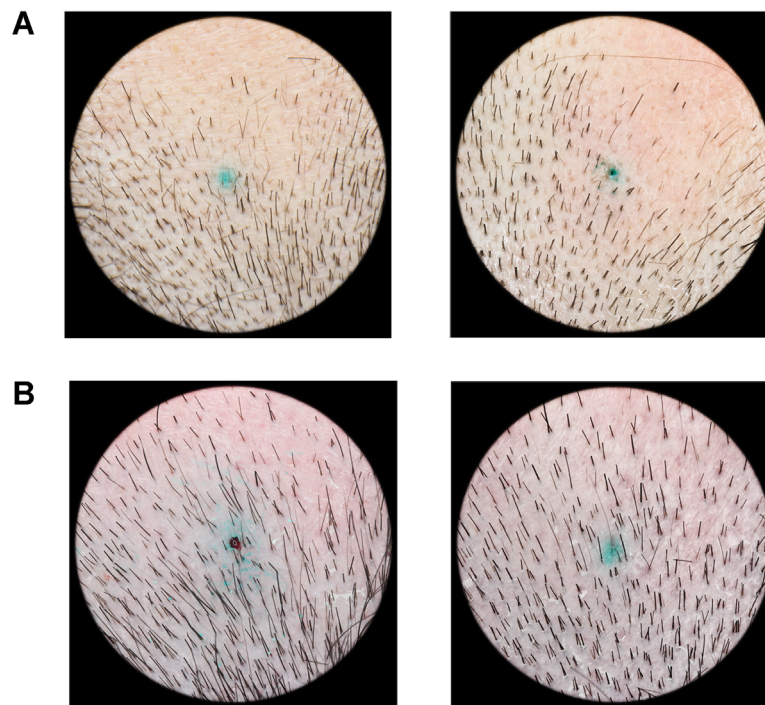Fig. 4. Pre and post treatment image examples for active treatment group subjects. Pre-treatment and 16 weeks post-treatment photo pairs are shown for two active treatment group subjects. Hair counts were 140 at baseline and 280 at 16 weeks in subject 69 (**A**), and 143 and 322, respectively in subject 79 (**B**). Note that some of the hairs subjectively appear to be thicker and more deeply pigmented after treatment.

TABLE 2. Baseline Hair Counts of Vertex Scalp Site

Site	Sham mean (SD) N med (min, max)	Active treatment mean (SD) N med (min, max)	P-value
1	111.1 (49.7) 13 109 (29, 218)	101.0 (44.7) 13 97.0 (49, 205)	0.442[a]
2	237.3 (99.1) 9 334.5 (121, 406)	201.3 (65.4) 9 213.0 (81, 276)	0.691[a]
P-Value	0.005[b]	0.002[b]	—

The baseline hair count data is shown for the placebo and active treatment group patients and by treatment site at baseline. The mean $\pm$ SD, the median and range (min, max) are shown.
[a]Two-sided Wilcoxon rank sum test.
[b]Two-sided unequal variance t-test.

TABLE 3. Baseline Hair Counts, End of Study Hair Counts, and Percent Increase by Treatment Group

Variable	Sham mean (SD) N med (min, max)	Active treatment mean (SD) N med (min, max)	P-value
Baseline	162.7 (95.9) 22 134.0 (29, 406)	142.0 (73.0) 22 135.0 (49, 276)	0.426[a]
Post treatment	162.4 (62.5) 19 159.0 (63, 330)	228.7 (102.8) 22 237.5 (83, 403)	0.016[a]
Percent increase	28.4 (46.2) 19 12.4 (−41.4, 134.3)	67.2 (33.4) 22 59.2 (19.8, 127.3)	0.001[b]

The baseline hair count data is shown for the placebo and active treatment group patients and by treatment site after 16 weeks of therapy. The mean $\pm$ SD, the median and range (min, max) are shown.
[a]Two-sided unequal variance t-test.
[b]Two-sided Wilcoxon rank-sum test.

TABLE 4. Baseline Hair Counts, End of Study Hair Counts, and Percent Increase by Treatment Group Excluding Control Subject 3 at Site 2

Variable	Sham mean (SD) N med (min, max)	Active treatment mean (SD) N med (min, max)	P-value
Baseline	151.1 (81.0) 21 132.0 (29, 345)	142.0 (73.0) 22 135.0 (49, 276)	0.680[a]
Post Treatment	158.2 (61.5) 18 155.0 (63, 330)	228.7 (102.8) 22 237.5 (83, 403)	0.011[b]
Percent Increase	32.3 (44.2) 18 12.6 (−29.6, 134.3)	67.2 (33.4) 22 59.2 (19.8, 127.3)	0.003[a]

The baseline hair count data is shown for the placebo and active treatment group patients and by treatment site after 16 weeks of therapy. The mean $\pm$ SD, the median and range (min, max) are shown. Subject 3 from site 2 is excluded from this analysis as he had a high baseline hair count and a very large decrease relative to all other study subjects.
[a]Two-sided Wilcoxon rank-sum test.
[b]Two-sided unequal variance t-test.

treatment was highly significant ($P < 0.0001$), but Study Site was not statistically significant ($P = 0.094$). This analysis indicates that the baseline counts were the primary reason the study sites differed and adjusting for that effect reduces the significance of study site but does not affect the treatment difference.

It should be noted that one subject in the control group at Site 2 started with a very large baseline count and had a very large decrease. To see if this subject had an undue influence on the results, an analysis was done which deleted this subject from consideration. The test for Site by Treatment interaction for this analysis had $P = 0.527$ indicating the absence of an interaction. Thus the data were pooled and the analysis proceeded as above. The results of that analysis with the subject deleted from the pooled data are provided in Table 4.

These results indicate that the statistically significant increase in percent hair counts was not due to the single subject with a large decrease from baseline. The estimated mean percent increase deleting one subject was about 35%. Adjustment for differences in baseline counts by study site actually improved the statistical significance level and the result was minimally affected by removing one Sham subject with a very high loss after treatment.

DISCUSSION

Various investigators have studied a variety of light sources, wavelengths, and treatment parameters for the treatment of alopecia with LLLT [27–30,32,33,35,36]. Most of these reports on the efficacy of LLLT for alopecia have been prospective, uncontrolled, open label studies, and

have not been confirmed by multi-center, randomized, double blind, controlled trials (RCT) [27–30,33,35,36].

We have reported the results for an RCT of the so-called TOPHAT 655 device. The present study employed a randomized, double-blind design, and used a true placebo via a helmet identical in appearance to the active device, with incandescent sources that glowed red but did not deliver measurable light to the subject's scalp and which operated at a temperature of $22.22 \pm 0.3°C$. Neither the active nor the sham devices delivered thermal energy to the scalp. Treatments were passive and did not depend on the user for delivery, aside from the subject placing the unit on the scalp, and activating the controller. This differs from the HairMax device studies that required the user to comb the scalp for a specified treatment time and employed a placebo device that was readily distinguished by the fact that it was a white light source [27–29,32,35].

Hair growth following exposure to low level laser therapy (LLLT) alone is not sufficient to document that photobiomodulation has occurred. Increases in hair counts were also observed in the sham or placebo group in the present study. These observations may represent a true placebo effect, since the sham device did not deliver thermal energy or measurable light at scalp level. However other explanations might also include seasonal variations in hair growth or other factors. This makes it important to include placebo and sham treatments in the study design and to conduct the investigation in such a manner as to minimize selection bias.

Several investigators have studied the effects of LLLT on hair growth in animal models [22,23,32,35]. Paradoxical hair growth after light based hair removal and other treatments in human subjects has also been observed with various laser and intense pulsed light sources [24–26,30].

The theory that is widely accepted is that LLLT, particularly at wavelengths in the red range as was used in this investigation, affects the functioning of the stem cells that cause hair growth. LLLT activates cytochrome c oxidase and increases mitochondrial electron transport [11–17], which leads to an increase in ATP and subsequent reversal of hair follicles from the dormant telogen stage of growth, to the active growth or anagen stage [27,28,30–32,34,35].

Analysis of non-radiated and radiated tissues has been employed to elucidate the tissue response and efficacy of the photobiomodulation effect [1,12–16,19–21]. However, the optimal wavelengths and treatment parameters remain indeterminate at this time. The present study was not designed to investigate alternative treatment regimes or parameters.

The ability of red light to stimulate hair follicle cellular proliferation and increase follicles in the anagen phase is supported by a preliminary study using the REVÅGE670 system (Apira Science, Boca Raton FL) [37]. This diode laser system operates at 670 nm and contains thirty 4 mW diode lasers affixed in a rotating helmet. Four subjects received two treatments per week for 6 weeks and one treatment per week for 6 weeks, totaling 18 laser treatments to the vertex of the scalp. Pretreatment and post treatment tissue samples were harvested after the 18th treatment. There were eight before and after biopsies taken from each subject. Four outcome measures were analyzed including: the number of hairs present, the presence of anagen hairs, the number of hairs containing Melanin, and the presence of Ki67 which is a marker of proliferating cells in the hair follicles. All of the subjects showed improvement in at least one of these measures on histological analysis [37].

The present study demonstrates that the use of LLLT at 655 nm as applied to the scalp on an every other day basis for 16 weeks (60 treatments) via the TOPHAT 655 device resulted in a significant improvement in patients who used the device. Specifically, there was a 35% increase in terminal hair counts in the laser group as compared to the control or sham treatment group ($P = 0.003$) in male patients who were 18–48 years of age and had IIa-V Hamilton–Norwood baldness patterns and were of Fitzpatrick Skin Types I-IV.

All of the patients in the study were able to apply and use the device as directed to self-administer their treatments at home. There were no side effects or adverse events reported by any of the study subjects at any time during the conduct of the study. This indicates that the device is safe for the unsupervised environment of home use.

SUMMARY

The present study demonstrates that that low level laser treatment of the scalp every other day for 16 weeks using the TOPHAT 655 device is a safe and effective treatment for androgenic alopecia in healthy males between the ages of 18–48 with Fitzpatrick Skin Types I-IV and Hamilton–Norwood IIa-V baldness patterns. Subjects receiving LLLT at 655 nm achieved a 35% increase in hair counts as compared to sham treated control patients in this multicenter RCT.

ACKNOWLEDGMENTS

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APPENDIX 1. Raw Hair Counts by Study Site and Treatment Group

Patient[a]	Site	Treatment	BL[c]	Posttrt[d]	Diff[e]	Pct bas[f]
1	1	Active	49	99	50	102.0408
2	1	Active	102	161	59	57.84314
3	1	Active	134	280	146	108.9552
4	1	Active	72	111	39	54.16667
5	1	Active	97	141	44	45.36082
6	1	Active	97	196	99	102.0619
7	1	Active	66	150	84	127.2727
8	1	Active	58	116	58	100
9	1	Active	81	125	44	54.32099
10	1	Active	143	322	179	125.1748
11	1	Active	205	329	124	60.4878
12	1	Active	145	273	128	88.27586
13	1	Active	64	83	19	29.6875
14	1	Sham	99	159	60	60.60606
15	1	Sham	99	125	26	26.26263
16	1	Sham	109	123	14	12.84404
17	1	Sham	29	63	34	117.2414
18	1	Sham	112	127	15	13.39286
19	1	Sham	102	109	7	6.862745
20	1	Sham	169	190	21	12.42604
21	1	Sham	42	83	41	97.61905
22	1	Sham	70	164	94	134.2857
23	1	Sham	218	241	23	10.55046
24	1	Sham	136	151	15	11.02941
25	1	Sham	132	182	50	37.87879
26	1	Sham	127	198	71	55.90551
27	2	Active	221	340	119	53.84615
28	2	Active	213	343	130	61.03286
29	2	Active	253	324	71	28.06324
30	2	Active	136	227	91	66.91176
31	2	Active	275	339	64	23.27273
32	2	Active	167	324	157	94.01198
33	2	Active	81	97	16	19.75309
34	2	Active	276	403	127	46.01449
35	2	Active	190	248	58	30.52632
36	2	Sham	161	160	−1	−0.62112
37[b]	2	Sham	249			
38[b]	2	Sham	345			
39	2	Sham	406	238	168	−41.3793
40	2	Sham	192	196	4	2.083333
41	2	Sham	159	112	−47	−29.5597
42[b]	2	Sham	179			
43	2	Sham	324	330	6	1.851852
44	2	Sham	121	134	13	10.7438

[a]Patient numbers were grouped for convenience not by order of presentation or randomization.
[b]Three subjects refused to return for the 16 week assessment at site 2.
[c]BL is the baseline count.
[d]Psttrt is the hair count after 16 weeks of treatment.
[e]Diff = Psttrt–BL.
[f]Pct_bas is the percent hair increase (decrease) at 16 weeks as a percent of baseline.