
# THE USE OF LOW-LEVEL LIGHT FOR HAIR GROWTH: PART I

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# THE USE OF LOW-LEVEL LIGHT FOR HAIR GROWTH: PART I

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No financial compensation was provided for the patients, physicians, or for study design.

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**ABSTRACT**

**Background and Objective:** Low-level-laser light therapy (LLLT) is a new therapy for the treatment of hair loss. It has received enormous media attention and tremendous marketing budgets from companies that sell the devices, but no independent, peer-reviewed studies have demonstrated its efficacy in this application. Here we investigate the efficacy of LLLT in enhancing hair growth.

**Study design/Patients and Methods:** A total of 7 patients were exposed to low-level-light therapy twice weekly for 20 minutes each time, over a period of 3 to 6 months. Five patients were treated for a total of 3 months and two were treated for 6 months. Videomicroscopic images were taken at baseline, 3 months, and 6 months, and analyzed for changes in vellus hair counts, terminal hair counts, and shaft diameter. Both videomicroscopic and global images underwent blinded review for evidence of subjective improvement. Patients also answered questionnaires assessing hair growth throughout the study. Neither patients nor physicians conducting the study received any financial compensation.

**Results:** The results indicate that on average patients had a decrease in the number of vellus hairs, increase in the number of terminal hairs, and increase in shaft diameter. However, paired t-testing indicated that none of these changes were statistically significant. Also, blinded evaluation of global images did not support an improvement in hair density or caliber.

**Conclusions:** Low-level light therapy may be a promising treatment option for patients who do not respond to either finasteride or minoxidil, and who do not want to undergo hair transplantation. This technology appears to work better for some people than for others. Factors predicting who will most benefit are yet to be determined. Larger, longer-term placebo-controlled studies are needed to confirm these findings, and demonstrate statistical significance, or refute them altogether.

**Key Words:** low-level laser therapy; hair; hair growth

## INTRODUCTION

There is anecdotal evidence to suggest that low-level-light, in the wavelength of 650-900 nm, but at significantly reduced powers of 5 milliwatts, can enhance hair growth. Hungarian researcher Endre Mester first used LLLT in 1967, when he was investigating whether laser radiation could cause cancer in mice.[1] He shaved off their dorsal hair and divided the mice into control and treatment groups, the latter receiving a low-powered ruby laser therapy (694 nm). He found no evidence of cancer in the mice, but did observe that the laser-treated group had faster hair regrowth. Since then, there have been scattered reports of paradoxical hair growth following laser treatment for hair removal.[2] It has been reported with the use of diode laser,[3] IPL,[4] and long-pulsed alexandrite lasers.[5,6] In addition ultraviolet light has been used to stimulate hair growth in the setting of alopecia areata.[7]

Exactly how these light sources can cause hair growth is unclear. Some suggested mechanisms include an activation of dormant hair follicles by low fluences, or the synchronization of hair growth cycles by direct light stimulation.[8] Basic science studies suggest that low level light may upregulate the production of ATP by mitochondria.[9,10,11] The mitochondrial respiratory chain has five major complexes that shuttle electrons from the intramembranous space into the matrix. By transferring electrons centrally, a proton gradient is built up in the intermembranous space. These protons enter back into the mitochondrial matrix through channels in the ATP synthase enzyme complex. Research has in fact shown that LLLT can increase the activity of Complexes II and IV in particular.[12]

What is difficult to establish is whether this effect on mitochondrial ATP production translates into actual hair growth. The findings above were found in a study on wound healing, where wounds were treated with AsGa (gallium arsenate, 904nm) low level laser. This and other studies have shown a clinical improvement in the rate of wound healing after LLLT.[13,14] Other studies indicate that an increase in ATP production in human neuronal cells in culture can improve neurologic recovery following strokes.[15,16] Likewise, peer-reviewed studies found it helpful in treating low back pain,[17] temporomandibular joint disorders,[18] and rheumatoid arthritis patients with carpal tunnel syndrome.[19]

Several companies have developed and now market devices that deliver low-level-light specifically for the purpose of treating hairloss. In 2007, the firm Lexington International (Boca Raton, FL) gained 510K approval for marketing their HairMax LaserComb as a medical device for hair growth.[20] Often these companies have performed their own research, without publishing it in the peer-reviewed literature. Only one study exists investigating the tensile strength of hairs after LLLT but it was not published in a peer-reviewed journal.[21] To date, no independent clinical trials have been performed to investigate the efficacy of LLLT for hair loss.

## MATERIALS AND METHODS

### Subjects

Seven subjects were enrolled in this study, 6 females and 1 male. All seven had a diagnosis of androgenetic alopecia, and were either on no medication or stable on minoxidil for a period greater than 6 months. We specifically excluded any patients who had recently started or stopped these medications to avoid the confounding effects that this might have created. We also excluded patients with a hair loss history less than 6 months. Their various demographics, stage and history of hairloss,

and previous treatments are listed in Table 1. Two patients (NL and LU) had undergone hair transplant surgeries, the last being over a year before study enrollment. These same two patients were also using hair extensions during the study.

At baseline, global clinical photographs were taken of patients under the same lighting conditions. Videomicroscopic photos were also taken using the Proscope digital handheld camera (Bodelin Technologies, Lake Oswego OR), at fixed positions on the central scalp, 15 and 20 cm posterior to the glabella (Figure 1). At each fixed position, images were taken through both ¼ cm and ½ cm windows, to calculate hair counts per $cm^2$.

Patients completed a baseline questionnaire in which they were asked to grade their hair loss, hair caliber (thickness), hair breakage, and describe to what extent the hair loss was affecting their social interactions. They repeated this questionnaire at the 3 month and 6 month intervals. Each answer was graded on a 1 – 10 scale where 10 was considered very severe and 1 was considered minimal.

The laser used in this study was provided by Sunetics International (Las Vegas, Nevada).[22] They provided no funding for any aspect of this study. Their device provides low-level light measuring 650 nm in wavelength at a fluence of 5 milliwatts. Patients sat under the 'hood' device for 20 minutes twice weekly (Figure 2). Eyeshields were placed over each patient's eyes for the full duration of each treatment.

**Objective Analysis**

All videomicroscopic images were then analyzed for changes in vellus hair count, terminal hair count, and hair shaft diameter, using specialized software (Trilogic Company, Moscow, Russia).[23] (Figures 3a, 3b) Paired t-testing of the data was performed using Graphpad Software, an online calculator for statisticians (http://www.graphpad.com/quickcalcs/ttest1.cfm).

**Subjective Analysis**

All before and after videomicroscopic and clinical images were randomized and graded subjectively by three blinded reviewers. Reviewers were instructed to grade each image from 0 to 10, where 0 represented no growth and 10 indicated full, thick hair growth. Both the clinical and videomicroscopic scores were averaged and compared before and after.

**RESULTS:**

**Vellus Hair Counts**

Vellus hair counts for each patient, taken at 15cm from the glabella are depicted in Figure 4. Five of the 7 patients had a decrease in the number of vellus hairs, while 2 patients had an increase. Paired t-testing indicates that on average, the patients at 3 months had 8.57 fewer vellus hairs than at baseline. However, this was not statistically significant (P= .3131).

Vellus hair counts taken at 20cm from the glabella are depicted in Figure 5. Six out of 7 patients had a decrease in the number of vellus hairs, while 1 patient had an increase. Paired t-testing indicates that on average, the patients at 3 months had 3.29 fewer vellus hairs than at baseline. Again, this was not statistically significant (P= .6474).

**Terminal Hair Counts**

Terminal hair counts for each patient, taken at 15cm from the glabella are depicted in Figure 6. Four out of 7 patients had an increase in the number of terminal hairs, while 3 patients had a decrease. Paired t-testing indicates that on average, the patients at 3 months had 7.57 more terminal hairs than at baseline. However, this was not statistically significant (P= .4183).

Terminal hair counts taken at 20cm from the glabella are depicted in Figure 7. Five out of seven patients had an increase in the number of terminal hairs, while 2 patients had a decrease. Paired t-testing indicates that on average, the patients at 3 months had 6.14 more terminal hairs than at baseline. Again, this was not statistically significant (P= .4441).

**Hair Shaft Diameter**

The average hair shaft diameter for each patient, taken at 15cm from the glabella is depicted in Figure 8. 4/7 patients had an increase in the width of their hairs, while 3 patients had a decrease. Paired t-testing indicates that at 3 months, patients had an average hair shaft diameter that was 1.0 micron wider than at baseline. However, this was not statistically significant (P=.5351).

The average shaft diameter taken at 20cm from the glabella is depicted in Figure 9. Three out of seven patients had an increase in the width of their hairs, while four patients had a decrease. Paired t-testing indicates that at 3 months, patients had an average hair shaft diameter that was .97 microns narrower than at baseline. Again, this was not statistically significant (P= .5161).

The above mentioned data is summarized in Table 2.

Subjective evaluation of clinical and videomicroscopic photos was provided by three blinded reviewers. All images were randomized prior to grading so the reviewers did not know which was before or after. The results of the clinical photo evaluation is provided in Table 3. We found that there was an increased score for 2 of the 7 patients, a decreased score for one patient, and no change in score for 4/7 patients.

The videomicroscopic photos were also randomized and scored from 1-10, in a way that the reviewers did not know whether images were before or after. The seven patients each had 4 videomicroscopic photos: taken at 15 and 20 cm, at baseline and at 3 months, providing a total of 28 image sets to compare before with after. We found that scores actually decreased in 21/28 sets of images, increased in 6/28 sets of images, and stayed the same in one set of images.

Finally, we assessed patients' overall opinion with the technology. Two patients (SF and AM) did not believe it was helping their hairloss, and withdrew from the study after three months. Two other patients (NB and NL) believed that it did help, and continue to use the laser. Three patients are not sure (JF, LU, RB) but are continuing on into the 6 month portion of the study.

**Adverse Events:**

One 62-year old patient (AM) was diagnosed with 2 basal cell carcinomas on the scalp, at the end of her three month session. She had very fair coloring and significant thinning over the top of her scalp. We believe that the development of these skin cancers was in no way related to the use of the laser light. Nonetheless, the patient preferred to withdraw from the study after reaching the 3-month mark. She was concerned about developing more skin cancers and did not believe she was benefiting enough from hair growth in order to continue with it.

Another patient (JF) reported occasional slight itching of the scalp. It was unclear whether this was a result of the laser or the minoxidil which she was using concurrently . She was given topical fluocinonide solution to use as needed for the itching.

**DISCUSSION**

Given that lasers have historically been used to *remove* unwanted hair, many physicians are debating whether the low-level-light lasers can really enhance hair growth. Numerous products are being marketed directly to consumers that employ low-level-light-therapy (LLLT) to theoretically thicken and promote the growth of existing follicles. However, these products have so far undergone few double-blind, placebo-controlled trials. Here we seek to obtain more information about this technology so that patients can be both informed and protected.

A major limitation of this study is the lack of a control group. We did not have sham devices available to us at the time of the study. In retrospect, we might have been able to cover some patient's eyes and position them in the chair but leave the device off. However, we were concerned that patient compliance might be poor knowing that they were coming to our office twice weekly, with a 50% chance that they were receiving placebo. Also, the small number of patients in the study made it difficult to obtain sturdy statistical findings. A larger and longer study is essential to obtain the necessary power to give more robust statistical results.

Several factors may have biased the reviewers blinded analysis of the images. Frequently, hair styling or combing in the clinical photographs was very different before and after. Ideally our next study could involve parting the hair down the middle and combing it flat to give a better idea of the width of the part. However, many of our patients came directly from the salon, and the extensions and styling they received there were essential for their self-esteem at work and around town. In addition, the Proscope camera settings occasionally varied so that videomicroscopic images had more or less glare. A brighter setting may created an appearance of less density. Likewise, hair color could also affect perceptions about density. Faint, gray hairs were less noticeable than naturally dark or dyed hairs.

In studies of minoxidil and finasteride, tattooing has been used to identify the exact location of the scalp that is being monitored. As this was an independent study, where no patients received monetary reimbursement, it was difficult to convince them to allow us to tattoo their scalps. Instead, we photographed the scalp at fixed positions of 15 and 20cm. Likewise, trimming the hairs can provide greater accuracy. Unfortunately we were not able to convince our female enrollees to let us trim their hair which was already thinning.

This study also raised questions about how well the laser as a 'hood" penetrates the scalp where follicles are present. Any amount of overlying hair has the potential to block access of the light to the scalp. Some lasers have been developed with rotating heads of lights, which may enhance penetration. It is possible that laser light delivered through a comb, which separates the hairs, may provide better penetration, but it is also for a shorter period of time.

In one case series, patients who developed paradoxical hair growth trended toward darker skin types, and had black hair.[6] Whether these patients truly are more susceptible to hair growth is uncertain, especially since most hair removal candidates have dark hair anyway. However it does raise the question of whether patients with darker hair and/or skin may be more responsive to treatment with LLLT. As we already know, standard hair removal lasers target the pigment in the hair follicle. Why would it not do the same at much lower fluences?

Finally, this study raises the question of what is the primary goal of this LLLT in the setting of hair growth. Ideally we would hope that LLLT can actually growing hair. However, the goal may be simply holding onto hair for a longer time. Minoxidil has proven useful in stopping the further loss of hair. Perhaps, even if this study did not demonstrate overt hair growth, the simple maintenance of hair may be enough. Likewise, perhaps three months is too short a time to demonstrate real hair growth. We advise all our patients, whether they use minoxidil, finasteride, or undergo hair transplantation, to allow a full 6-8 months to see the effect of the treatment on new hair growth. More studies are needed to fully assess the role of this new technology in hair growth.

**Conclusion:**

This study represents the first independent study of LLLT and hair growth. We hope this spurs others to design other independent studies to confirm or refute our findings. Multiple independent peer-reviewed studies are mandatory to define the appropriate roles of these devices in the treatment of hair loss. While seemingly safe, the paucity of peer-reviewed studies validating LLLT for hair loss makes it hard to convince physicians of its efficacy. We have another ongoing study using the HairMax LaserComb and will analyze the data we obtain in that study with the same software used here.

No matter how we implement lasers to treat patients with hair loss, we must first identify the etiology. Frequently conditions such as lichen planopilaris or telogen effluvium may present in a way that mimics androgenetic alopecia. We should be sure that the patients undergo medical evaluation and biopsy where necessary. This crucial step may be left out when treatments such as LLLT are available directly to the public without a prescription. Consumers should be protected from buying expensive items that may not be applicable or aggressive enough for their type of hair loss. Likewise, physicians should be open to the use of such devices where other options have failed, so long as reproducible studies can demonstrate their safety and efficacy.

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23. Trichoscience version 1.5 will be available in June 2008 through Merz Pharmaceuticals (Frankfurt, Germany).

**TABLES**

**Table 1: Patient demographics**

| Patient | Age | Gender and Race | Hair color | Baseline Diagnosis | Time in Study (months) | History of hair loss | Concurrent Treatments | Previous Treatments |
|---|---|---|---|---|---|---|---|---|
| N.L. | 58 | WF | Br/grey | Ludwig II-III | 6 | 7 yrs | Minoxidil, extensions | Minoxidil, Finasteride, Hair transplant surgery in 2004 and 2007 |
| N.B. | 40 | WF | Black | Ludwig I | 6 | 1 yr | None | Minoxidil, Biotin |
| S.F. | 65 | AAF | Br/grey | Ludwig II | 3 | 5-6 yrs | None | Biotin |
| R.B. | 34 | WM | Brown | Norwood stage IV | 3 | 10 yrs | Finasteride | Minoxidil |
| A.M. | 62 | WF | Blonde | Ludwig II | 3 | 10 yrs | None | Biotin supplements |
| J.F. | 58 | WF | Br/grey | Ludwig I | 3 | 30 yrs | Minoxidil | Minoxidil |
| L.U. | 46 | WF | Blonde | Ludwig II | 3 | 20 yrs | Extensions | Minoxidil, Hair transplant surgery in 2005 |

**Table 2: Vellus and Terminal Hair counts and Hair shaft Diameters**

| | Mean at Baseline | Mean at 3 Months | Delta | P-value |
|---|---|---|---|---|
| **Vellus Hair Counts at 15 cm** | 52.43 | 43.86 | -8.57 | .3131 |
| **Vellus Hair Counts at 20 cm** | 48.86 | 45.57 | -3.29 | .6474 |
| **Terminal Hair counts at 15 cm** | 64.14 | 71.71 | +7.57 | .4183 |
| **Terminal Hair counts at 20 cm** | 82.14 | 88.29 | +6.14 | .4441 |
| **Hair Shaft diameter at 15cm (microns)** | 27.98 | 28.98 | +1.00 | .5351 |

| | | | | |
|---|---|---|---|---|
| **Hair Shaft diameter at 20cm (microns)** | 29.74 | 28.77 | -.97 | .5161 |

**Table 3: Blinded evaluation of clinical and videomicroscopic images**

| Patient | Reviewer 1 | Reviewer 2 | Reviewer 3 | Mean Score | Delta |
|---|---|---|---|---|---|
| N.L. Before | 4 | 4 | 6 | 4.67 | Increase |
| After | 7 | 7 | 7 | 7 | |
| N.B. Before | 9 | 10 | 10 | 9.67 | Same |
| After | 9 | 10 | 10 | 9.67 | |
| S.F. Before | 4 | 6 | 7 | 5.67 | Decrease |
| After | 5 | 6 | 4 | 5.00 | |
| R.B. Before | 7 | 5 | 7 | 6.33 | Same |
| After | 7 | 5 | 7 | 6.33 | |
| A.M. Before | 6 | 7 | 5 | 6.00 | Same |
| After | 6 | 7 | 5 | 6.00 | |
| J.F. Before | 8 | 7 | 10 | 8.33 | Same |
| After | 8 | 7 | 10 | 8.33 | |
| L.U. Before | 5 | 5 | 6 | 5.33 | Increase |
| After | 5 | 5 | 7 | 5.67 | |

**FIGURE LEGEND**

Figure 1. Proscope videomicroscope.

Figure 2. Photo of patient under Sunetics laser.

Figure 3a. Photo of ¼ cm cutout of videomicroscope images showing vellus hair count (in red) and terminal hair count (in green).

Figures 3b. Photo of ¼ cm cutout of videomicroscope image showing assessment of mean hair shaft diameter. All measurements shown were multiplied by a factor of 2.77 for conversion to microns.

Figure 4. Vellus Hair Counts at 15 cm from glabella.

Figure 5. Vellus Hair counts at 20 cm from glabella.

Figure 6. Terminal hair counts at 15 cm from glabella.

Figure 7. Terminal hair counts at 20 cm from glabella.

Figure 8. Hair shaft diameter at 15 cm from glabella.

Figure 9. Hair shaft diameter at 20 cm from glabella.

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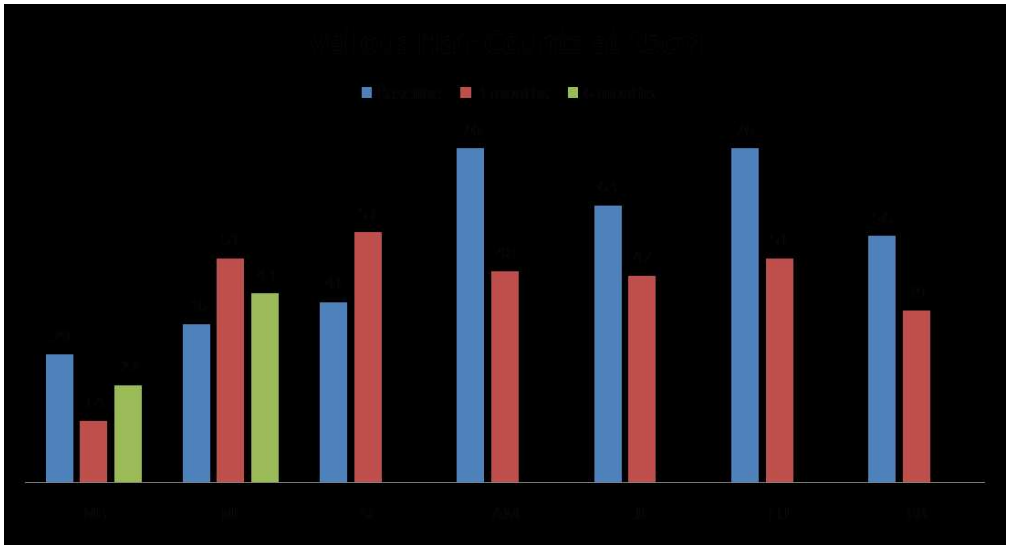
592x393mm (96 x 96 DPI)

169x127mm (96 x 96 DPI)


169x127mm (96 x 96 DPI)



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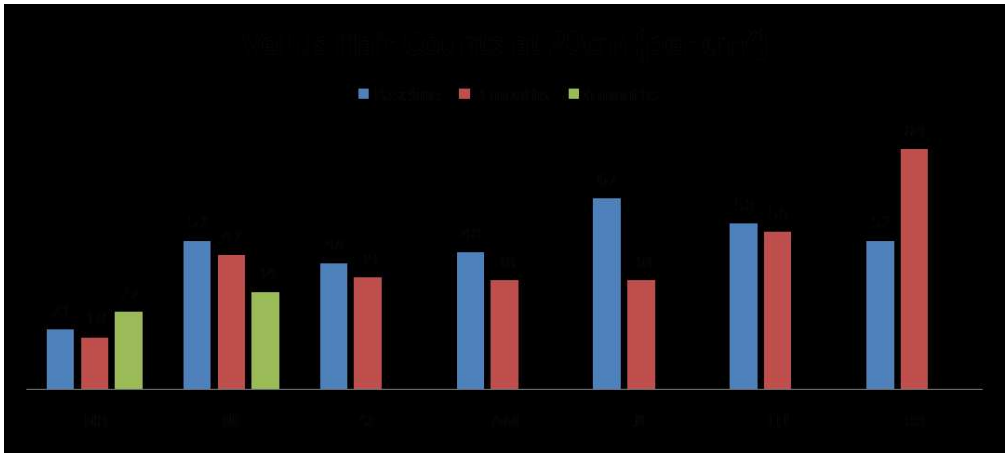

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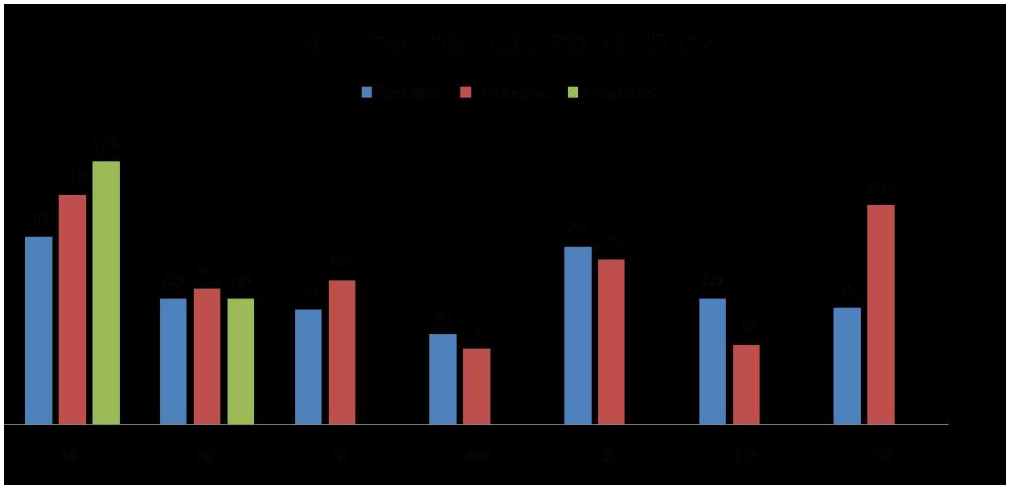

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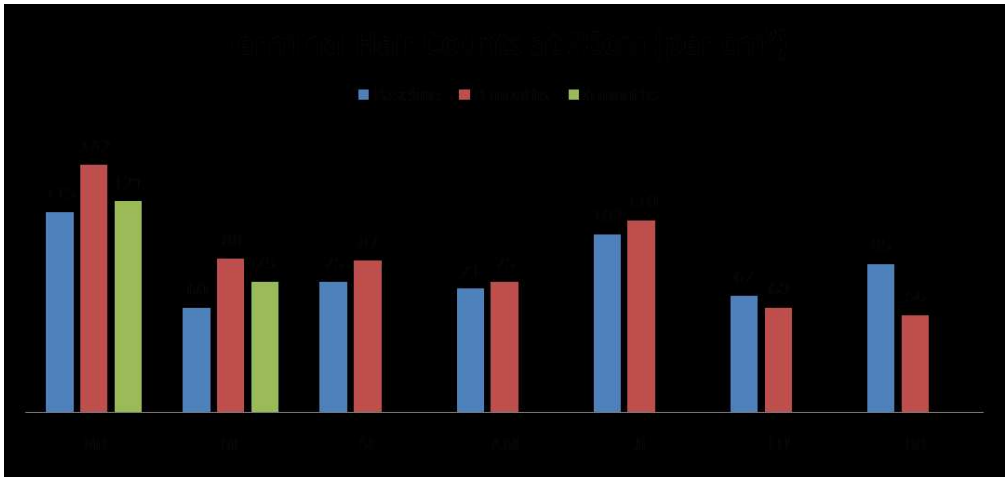

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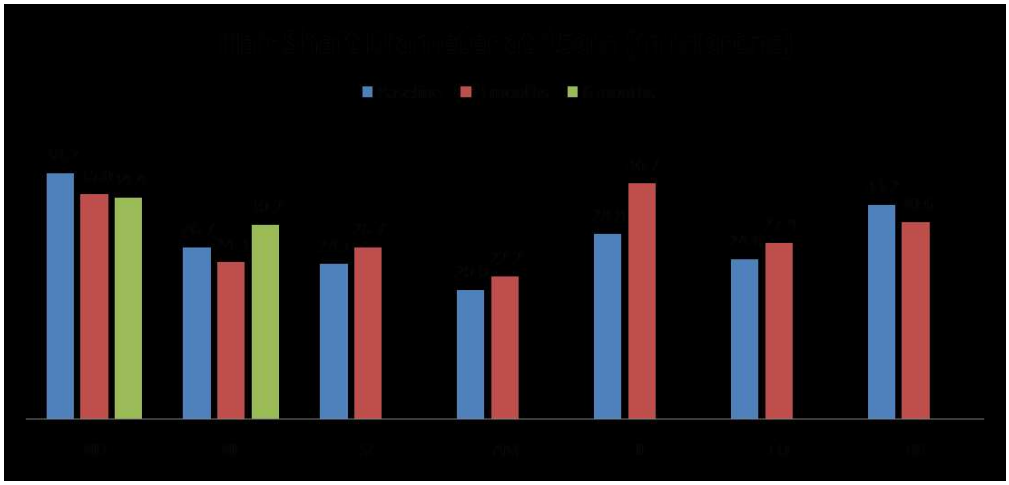

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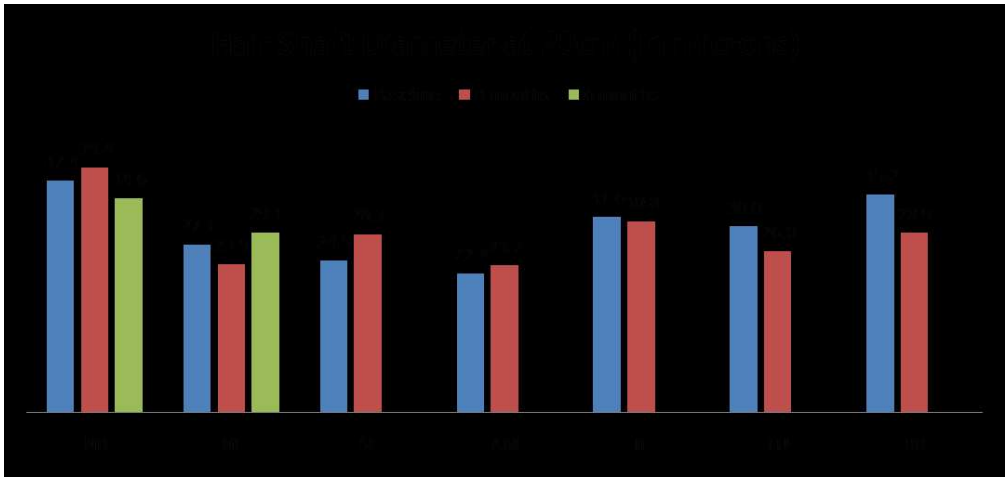

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