Artigo

EVALUATION OF THE EFFECTIVENESS OF HIGH-INTENSITY MICROFOCUSED ULTRASOUND AS A NON-INVASIVE METHOD FOR REDUCING FAT LOCATED IN THE ABDOMINAL REGION: PILOT STUDY

AVALIAÇÃO DA EFETIVIDADE DO ULTRASSOM MICROFOCALIZADO DE ALTA INTENSIDADE COMO MÉTODO NÃO INVASIVO PARA REDUÇÃO DE GORDURA LOCALIZADA NA REGIÃO ABDOMINAL: ESTUDO PILOTO

EVALUACIÓN DE LA EFICACIA DEL ULTRASONIDO MICROFOCUSADO DE ALTA INTENSIDAD COMO MÉTODO NO INVASIVO PARA REDUCIR LA GRASA LOCALIZADA EN LA REGIÓN ABDOMINAL: ESTUDIO PILOTO

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ABSTRACT: The search for non-invasive techniques to reduce localized fat in the abdominal region has become increasingly popular in contemporary societies. Among these techniques is High Intensity Microfocused Ultrasound (HIFU), which, by delivering high intensities of energy in a focused manner, promotes the rupture of adipocyte membranes, destroying them. This study aims to evaluate the effectiveness of HIFU as a non-invasive intervention for reducing localized fat in the abdominal region. The research was based on an experimental, qualitative and quantitative pilot study with 7 volunteers who had localized adiposity, who underwent a HIFU session. The analysis took place using dermal ultrasound scans of the thickness of subcutaneous fat, carried out before the treatment, immediately after the session and also during a 4-week follow-up period. In order to assess the accuracy and consistency of the dermal ultrasound measurements, the mean and standard deviation of each set of data were calculated. The ultrasound analyses confirmed the reduction in adipose tissue, providing an objective assessment of the results. HIFU proved to be a promising non-invasive approach for reducing abdominal adipose tissue, regardless of whether it is malleable or more compact adipose tissue.

KEYWORDS: HIFU, localized fat, adipose tissue, non-invasive.
abdominal, independiente de se tratar de un tejido adiposo maleable o más compacto.

PALAVRAS-CHAVE: HIFU, gordura localizada, tejido adiposo, não invasivo.

RESUMEN: La búsqueda de técnicas no invasivas para reducir la grasa localizada en la región abdominal ha cobrado protagonismo en las sociedades contemporáneas. Entre estas técnicas se encuentra el Ultrasonido Microfocalizado de Alta Intensidad (HIFU), que, mediante la entrega de altas intensidades de energía de manera focalizada, promueve la disrupción de las membranas de los adipocitos, destruyéndolas. Este estudio tiene como objetivo evaluar la efectividad del HIFU como intervención no invasiva para reducir la grasa localizada en la región abdominal. La investigación se basó en un estudio piloto experimental, cualitativo y cuantitativo, con 7 voluntarios que presentaban adiposidad localizada. El análisis se realizó mediante ecografía dérmica del espesor de la grasa subcutánea, realizada antes del tratamiento, inmediatamente después de la sesión y también durante el seguimiento durante un período de 4 semanas. Para evaluar la precisión y consistencia de las mediciones realizadas con ultrasonido dérmico, se calcularon la media y la desviación estándar de cada conjunto de datos. Los análisis ultrasónicos confirmaron la reducción del tejido adiposo, proporcionando una valoración objetiva de los resultados. Se ha demostrado que HIFU es un enfoque no invasivo prometedor para reducir el tejido adiposo abdominal, independientemente de si es tejido adiposo maleable o más compacto.

PALABRAS CLAVE: HIFU, grasa localizada, tejido adiposo, no invasivo.

1. Introduction

Techniques for reducing localized fat have been developing in contemporary times, not only due to technological advances but also due to society’s concern for health. Having an appearance that aligns with the desired self-image contributes to self-confidence, self-esteem and emotional
well-being, creating complete well-being, involving not only the absence of disease (WHO, 1946).

There are different dermatological procedures that are effective in reducing localized adiposity, both invasive and non-invasive. The best-known invasive procedure for this purpose is surgical liposuction, which is capable of removing considerable volumes of localized fat in different areas of the body. Although of great value, surgical procedures bring with them some risks during and even after the procedure, such as adverse effects from anesthesia, post-procedure pain, infections, inflammation and scarring. Considering these risks and the time required for recovery and care, liposuction becomes unfeasible for non-obese patients who have fat deposition in a focal area (Hong et al, 2019).

Non-invasive procedures have been gaining prominence in the aesthetic market, as they supposedly have lower costs, lower risks of complications and, in most cases, there is no need to interrupt daily activities for recovery and care. Among the most widely used non-invasive techniques today is high-intensity focused ultrasound (Fatemi, Kane 2010).

High Intensity Focused Ultrasound, also called HIFU, uses high intensities of energy in a focused manner to promote the destruction of adipocytes, consequently reducing the thickness of subcutaneous adipose tissue (Toscan, Zanol 2017).

Adipose tissue is the body's energy store (in the form of triglycerides). In terms of its structure, function, color and location, it can be differentiated into yellow adipose tissue (unilocular) and brown adipose tissue (multilocular). According to the World Health Organization (WHO), around 20% of an adult's total body weight is made up of unilocular adipose tissue, i.e. yellow fat. The fat present inside the adipocytes is derived from the excess of calories ingested in relation to those expended by the body (Borges FS, 2006).
HIFU can be irradiated into tissues without causing any damage, but when the ultrasound beam is emitted with sufficient energy and is directed at a precise point, the energy concentrated at the focal point causes the local temperature to rise rapidly, thus having enough force to cause microthermal tissue damage, i.e. irreversible cell death through coagulative (ischemic) necrosis, without damaging the tissues surrounding or overlying the region (Kennedy; Haar; Cranston, 2003).

Microthermal injuries to adipose tissue cause the membranes of fat cells to rupture, causing their contents, such as triglycerides and fatty acids, to be released into the interstitium. In this way, macrophages are recruited to the area and phagocytize all the cell debris and extravasated lipids (Melo, 2018).

In contemporary times, the search for a healthy body highlights the value society places on well-defined body contours. Thus, in the midst of so many techniques, many of which are evolving, high-intensity microfocused ultrasound represents an up-and-coming technology for reducing localized fat as a non-invasive method, using focused ultrasonic waves, preventing the need for surgical and/or invasive procedures. In this context, the study analyzes the effectiveness of microfocused ultrasound in reducing localized fat in the abdominal region by evaluating the thickness of the fat layer.

2. Methodology

2.1 Type of Study

This is an experimental, qualitative and quantitative case study carried out in March and June 2024, after approval by the UNIFEMM Faculty Research Ethics Committee under opinion number 6.661.470 and after the signing of the Free and Informed Consent Form by the research volunteers. The study was carried out in the Research and Development Department of Contourline
Equipamentos Médicos e Diagnósticos Ltda, based in the city of Sete Lagoas, Minas Gerais.

2.2 Sample

The sample consisted of 7 volunteers of both sexes, who underwent an assessment to select them according to the inclusion categories. In the inclusion criteria, the participants had to be over 20 years old, have localized abdominal adiposity, with a fat layer equal to or greater than 2.5 cm, BMI less than or equal to 29.9/30 Kg/m².

2.3 Procedures

After selection, the volunteers were informed about the procedure to be carried out and then underwent an anamnesis, where general assessment information, anthropometric measurements and ultrasonic and photographic records were collected.

All the volunteers underwent a single session of HIPRO® high-intensity microfocused ultrasound from Contourline Equipamentos Médicos e Diagnósticos Ltda, in the abdominal region. Before, immediately after the treatment and during the long-term follow-up of 4 weeks, 15 and 30 days after the session, the thickness of the abdominal adipose tissue was measured using dermal ultrasound, performed 5 cm below the umbilical scar to analyze the lower central abdomen, 5 cm to the right and 5 cm to the left, totaling 3 points of analysis in the lower abdomen, as well as anthropometric measurements taken 5 cm above and 5 cm below the umbilical scar, weight, height, abdominal circumference and plicometry.

In the supine position, the lower abdominal region was delimited, more specifically below the umbilical scar, with a delimitation of 10cm² on the right side and 10cm² on the left side for the volunteers to receive the application
of microfocused ultrasound. The parameters used (table 1) were common to all participating volunteers, in order to avoid discrepancies between the results, the frequency was 10Hz, with energy at 2J and around 3500 shots per 10cm², this at all depths of 10, 8 and 6 mm, applied respectively.

Table 1 - Application parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (Hz)</td>
<td>10 Hz</td>
</tr>
<tr>
<td>Energy (J)</td>
<td>2 J</td>
</tr>
<tr>
<td>Depths (mm)</td>
<td>10/8/6 mm</td>
</tr>
<tr>
<td>No. of shots/ 10 cm²</td>
<td>3500</td>
</tr>
</tbody>
</table>

Source: Prepared by the authors.

2.4 Data Analysis

To assess the accuracy and consistency of the dermal ultrasound measurements, the mean and standard deviation of each data set were calculated. The mean was obtained by adding up all the values in each set and dividing by the number of observations, providing a measure of central tendency that represents the typical value of the measurements. The standard deviation was calculated as the square root of the mean of the squares of the differences between each value and the mean, quantifying the variability and dispersion of the measurements around the mean. These calculations made it possible to identify both the centrality and consistency of the measurements, where a lower standard deviation indicated greater precision and less variability in the data.

3. Results and Discussion

A total of 7 individuals (4 women and 3 men) were included in the study. The average age of the participants was 34.14 years, with an average
height of 1.65 cm, a weight of 68.15 with a standard deviation of ±16.06 and an average Body Mass Index (BMI) of 24.24 Kg/m² (Table 2).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Average (standard deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>34.14 (±8.1)</td>
</tr>
<tr>
<td>Weight</td>
<td>68.15 (±16.06)</td>
</tr>
<tr>
<td>Height</td>
<td>1.65 (±0.13)</td>
</tr>
<tr>
<td>BMI</td>
<td>24.24 (±2.68)</td>
</tr>
</tbody>
</table>

Source: Prepared by the authors.

On average, all the volunteers showed a reduction in the thickness of the fat layer after treatment. The reductions ranged on average from 0.85 mm to 2.84 mm in the lower abdomen as a whole (Table 3), indicating a positive effect on reducing abdominal fat in all cases. The standard deviations, ranging from 0.27 mm to 2.5 mm, show a variation in the individual response to treatment, these variations may depend on various factors, including the nature of each volunteer's abdominal fat, which may be more malleable or more compact.

Malleable fat can respond more quickly to treatment, resulting in more significant reductions in the thickness of the fat layer. On the other hand, compact fat may be more resistant, leading to smaller reductions. Therefore, the effectiveness of the treatment may be related not only to the amount of fat present, but also to its quality and physical characteristics, thus influencing individual results.

The dermal ultrasound was performed on three different areas of the lower abdomen of each volunteer, and the data presented (Table 3) are the results of an overall average of these measurements, ensuring a more comprehensive and accurate assessment of the thickness of the fat layer. When looking at the individual areas of the lower abdomen, such as 5 cm below the umbilical scar and 5 cm to the side, it is possible to see a reduction
of 2.51 mm, 3.01 mm and 2.38 mm respectively on the ultrasound (figure 1, figure 2, figure 3).

Table 3 - Fat layer thickness (mm) - Lower abdomen

<table>
<thead>
<tr>
<th>Volunteer</th>
<th>Before (average ± SD)</th>
<th>After (average ± SD)</th>
<th>Difference (average ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16.91 ± 1.0</td>
<td>15.04 ± 2.5</td>
<td>1.80 ± 1.0</td>
</tr>
<tr>
<td>2</td>
<td>20.91 ± 1.6</td>
<td>20.24 ± 1.3</td>
<td>0.54 ± 1.7</td>
</tr>
<tr>
<td>3</td>
<td>16.29 ± 1.4</td>
<td>14.05 ± 1.9</td>
<td>2.23 ± 1.0</td>
</tr>
<tr>
<td>4</td>
<td>8.78 ± 1.7</td>
<td>7.31 ± 0.65</td>
<td>1.80 ± 1.1</td>
</tr>
<tr>
<td>5</td>
<td>20.06 ± 0.87</td>
<td>17.42 ± 1.1</td>
<td>2.63 ± 0.27</td>
</tr>
<tr>
<td>6</td>
<td>14.07 ± 0.93</td>
<td>11.23 ± 1.6</td>
<td>2.84 ± 0.73</td>
</tr>
<tr>
<td>7</td>
<td>9.33 ± 0.43</td>
<td>8.48 ± 0.30</td>
<td>0.85 ± 0.70</td>
</tr>
</tbody>
</table>

Source: Prepared by the authors.

Figure 1. Ultrasound of the representative assessment of the thickness of the central fat layer. The thickness of the fat at baseline (top) and 36 days after treatment (bottom) shows a reduction in the adipose layer and an increase in the fibrous septae.

Source: Prepared by the authors.
Figure 2. Ultrasound of the representative assessment of the thickness of the lateral/right adipose layer of the abdomen. The thickness of the fat at baseline (top) and 36 days after treatment (bottom) shows a reduction in the fat layer and an increase in the fibrous septae.

Source: Prepared by the authors.
Figure 3. Ultrasound of the representative assessment of the thickness of the lateral/left adipose layer of the abdomen. The thickness of the fat at baseline (top) and 36 days after treatment (bottom) shows a reduction in the fat layer and an increase in the fibrous septae.

For Jewell et al., HIFU is a suitable option for improving the body contour of non-obese people, as this technology promotes the rupture of adipocyte membranes through molecular vibration transmitted by ultrasonic waves directed at a focal point. Coleman et al. further explains that ultrasonic waves generate cycles of compression and expansion, creating bubbles that increase in size until they implode, thus inducing rupture of the fat cell membrane.

The results of this study indicate that HIFU is an effective approach for reducing localized fat without the need for surgical procedures, in line with previous studies documenting the effectiveness of HIFU in reducing subcutaneous adipose tissue, with a consequent reduction in abdominal
anthropometric measurements. Kim et al. reported a reduction of 2.8 cm in abdominal circumference, similar to the reduction observed in our study, which ranged between 2 and 4 cm.

There were no records or reports of treatment-related adverse events, either immediate or afterwards, such as bruising, edema, dysesthesia or pain, consistent with expectations based on HIFU's mechanism of action.

4. Conclusion

Based on the results, HIFU appears to be a promising non-invasive option for the treatment of localized fat in the abdominal region, promoting a reduction in the thickness of the adipose layer in the abdomen. In order to achieve better results, future studies should consider using a variety of protocols, adapting the depth of treatment to the fat thickness of each individual, as well as using a larger sample to better understand the interactions between the treatment parameters and the results achieved, thus contributing to the development of even more effective protocols for the use of HIFU.
References


