Effect of Pulsed Magnetic Field on Platelets Count and Coagulation Process in Healthy Subjects

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Abstract

Background: Magnetic field is now recognized by the 21st century medicine as real physical entities that promise the healing of various health problems. In the last few decades, various studies refer to biological effect of magnetic field exposure have been in progress. Most of studies carried out on mice, rat and little on human showed that magnetic fields induced changes in hematological parameters in these organisms.

Purpose: To investigate the effect of pulsed magnetic field on platelets count and coagulation process in healthy subjects.

Methods: Thirty-one participants divided into two groups, a study Group (A) (23 subjects), and a control Group (B) (8 subjects). Their ages ranged from 25-40 years. They were selected randomly from the staff members working at the Police Authority Hospital El-Agouza. They were free from any health problems and not previously treated by magnetic field. Group (A) received magnetic field for 12 sessions successively over one month by the rate of 3 sessions per week, with low frequency (10HZ), low intensity (10G) and for 20 minutes, while Group (B) didn’t be exposed to magnetic field just placement in the device as a placebo. The subjects were evaluated pre and post exposure for both platelet count and INR.

Results: Showed that Group A that received pulsed magnetic field had significant increase of platelets count and significant reduction of INR, while the other group had no significant difference in both of them.

Conclusion: Pulsed magnetic field increases platelets count and decreases coagulation.

Key Words: Pulsed magnetic field – Blood coagulation – Platelets – INR.

Introduction

PULSED Magnetic Field (PMF) therapy is a form of complementary medicine which is clinically used in the treatment of fractures, wounds, heart disease, recurrent headache disorder and osteoporosis [1,2]. Many clinical and basic research studies have shown that MF was effective not only on healing long bone nonunion, but also on cancellous bone graft incorporation [3], soft tissue injuries [4], and peripheral nerve injury [5].

Platelets are biconvex discs, fragments of cytoplasm 2-3 µm in diameter [6], found only in the blood of mammals. Platelets are produced in bone marrow form by budding off from megakaryocytes, production of megakaryocytes is controlled by the hormone, thrombopoietin produced by liver and kidney. One megakaryocyte can produce 5,000-10,000 platelets [7]. The normal concentration of platelets in the blood is between 150,000-300,000 per microliter. Their main functions are to cover damaged blood vessels, aggregate to one another and facilitate the generation of thrombin. The initial signal for platelet deposition and activation is stimulation by an agonist; exposure of the sub-endothelium caused by endothelial cell denudation is almost always the primary agonist [8].

Hemostasis is achieved via delicate balance between the coagulation and fibrinolysis (a process by which fibrin is dissolved into soluble components) systems [9]. Normal hemostasis is the result of a well-regulated set of processes that perform two important functions: Keeping the blood in the fluid state and free from clots in normal vessels and in doing a rapid and localized hemostatic plug at the vascular injury site [10]. In abnormal hemostasis, inappropriate blood clotting occurs to stop blood flow in the vascular compartment [11].

Material and Methods

This study was conducted in the Police Authority Hospital El-Agouza in the period from April
till June 2016. Thirty-one healthy subjects were selected from the staff members of Physical Therapy Department of Police Authority Hospital El-Agouza. They were free from any health problems. They were divided into two groups, Group (A) (Study group) received magnetic field with 12 sessions successively over one month period by the rate of 3 sessions per week, with low frequency (10HZ), low intensity (10G) and for 20 minutes. While Group (B) (control group) didn't be exposed to magnetic field just placement of the device as a placebo effect. Subjects who participated in this study signed a written consent forms approved by the Ethical Committee of the Faculty of Physical Therapy, Cairo University.

**Inclusion criteria:**

The subjects were healthy, non-smokers with no hematological problems, their age was ranged from 25-40 years, they were selected from the staff members working at Department of Physical Therapy and they were not previously treated by MF therapy.

**Exclusion criteria:**

The subjects with hepatic diseases, cardiac diseases and chest diseases, smokers, subjects with hematological problems. And contraindications to magnetic exposure (pacemaker, malignancy, terminal or rapidly progressive illness).

**Instrumentations:**

- Equipment used for evaluation:
  1- **Platelet counts:** Complete Blood Count (CBC): Ethylene Diamine Tetra Acetate (EDTA) tubes (purple top) using blood analyzer for platelets count.

  **Equipements needed:** Ethylene Diamine Tetra Acetate (EDTA) tubes (purple top), blood analyzer for platelets count.

  - **Equipments needed:** Ethylene Diamine Tetra Acetate (EDTA) tubes (purple top), blood analyzer for platelets count (light microscope), tubes and kits for blood samples, cotton balls, 70% alcohol.

  **Procedure:**

  A- Purple top tubes should be 50-60% full, do not overfill tubes.

  B- Gently mix specimen by inverting 5-10 times and place it on a rocker for up to 30 minutes, then refrigerate at 2-8°C. When a differential is required as part of a CBC, slides must be prepared within 12 hours of blood collection.

  C- Refrigerated EDTA blood is stable for CBC for up to 24 hours. Clotted or hemolyzed specimens are unacceptable. Check for clots by using a clean wooden applicator stick and gently swirling blood in tube.

  D- EDTA microtainers must be “shaken” 10-15 times to overcome the surface tension within the tube.

  2- **International Normalized Ratio (INR):**

  The International Normalized Ratio (INR) is the ration of a patient’s prothrombin time to a normal (control) sample.

  \[
  \text{INR} = \left( \frac{\text{PT}_{\text{test}}}{\text{PT}_{\text{normal}}} \right)^{\text{1st}}
  \]

  The reference range for prothrombin time depends on the analytical method used, but is usually around 12-13 seconds and the INR in absence of anticoagulants therapy is 0.8-1.2. The target range for INR in anticoagulant use is 2 to 3. In some cases, if more intense anticoagulation is thought to be required, the target range may be as high as 2.5-3.5 depending on the indication for anticoagulation [12].

  **Equipements needed:** Kits for measuring prothrombin time, stop watch, blood tubes, cotton balls, 70% alcohol, recording sheets.

  **Procedure:**

  A- Prothrombin time is typically analyzed by the laboratory technologist on an automated instrument at 37°C (as a nominal approximation of normal human body temperature).

  B- Blood samples can be obtained either by venipuncture or from an indwelling catheter.

  C- Blood is drawn into a test tube containing liquid sodium citrate, which acts as anticoagulants by binding the calcium in the sample.

  D- The blood is mixed, and then centrifuged for 10 to 15 minutes with Ca. 2000gm. To separate blood cells from plasma (as prothrombin time is most commonly measured using blood plasma).

  E- A sample of the plasma is extracted from the test tube and placed into a measuring test tube.

  **Note:** For an accurate measurements, the ratio of blood to citrate needs to be fixed and should be labeled on the side of the measuring test tube, many laboratories will not perform the assay if the tube is under-filled and contains a relatively high concentration of citrate, the standardized dilution of 1 part anticoagulants to 9 parts whole blood is no longer valid.

  F- Next an excess of calcium (in a phospholipid suspension) is added to the test tube, thereby reversing the effects of citrate and enabling the blood to clot again.
G- Finally in order to activate the extrinsic/tissue factor clotting cascade pathway, tissue factor (factor III) is added and the time the sample takes to clot is measured optically. Some laboratories use a mechanical measurement, which eliminates interferences from lipemic and icteric samples. The prothrombin ration is the prothrombin time for a patient sample divided by the results for control plasma.

Equipment used for treatment:
The magnetic field apparatus which was used is magnetomed 8400. It is a device for magnetotherapy, and consists of an appliance, motorized bed and solenoids. The appliance must be connected to electrical supplying 230±10% at a frequency of 50/60HZ with earth connection. It can generate pulsed magnetic field up to 100Hz max and intensity varies according to the type of solenoid. The intensity and spatial lay out of the generated magnetic field depend on the type of solenoid used.

Procedures:
Group (A) (study group) received magnetic field with 12 sessions successively over one month period by the rate of 3 sessions per week, with low frequency (10HZ), low intensity (10G) and for 20 minutes. While Group (B) (control group) didn’t be exposed to magnetic field just placement of the device as a placebo effect.

Results
The current study was conducted on 31 subjects (15 females and 16 males). They were assigned randomly in two groups, Group A consisted of 23 subjects (11 females and 12 males) with mean age, weight and height values of 31.5±4.67 years, 74.04±10.72kg, and 170.91±8.35cm respectively. Control group consisted of 8 subjects (4 females and 4 males) with mean age, weight, and height values of 31.5±3.7 years, 73.37±8.66kg, and 170.125±8.28cm respectively. As indicated by the independent t test, there were no significant differences (p>0.05) in the mean values of age, weight, and height between both tested groups.

Table (1): Physical characteristics of patients in both groups.

<table>
<thead>
<tr>
<th>Items</th>
<th>Study group</th>
<th>Control group</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td></td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>31.04±4.67</td>
<td>31.5±3.7</td>
<td>-0.249</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>74.04±10.72</td>
<td>73.37±8.66</td>
<td>0.159</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>170.91±8.35</td>
<td>170.125±8.28</td>
<td>0.23</td>
</tr>
</tbody>
</table>

*p*: Standard Deviation.  
S: Significance.  
NS: Non-Significant.

The sex distribution of study group revealed that there were 11 female with reported percentage of 56.5% and 12 males with reported percentage of 43.5%. The sex distribution of control group revealed that there were 4 female with reported percentage of 50% and 4 males with reported percentage of 50% as shown in (Table 2). Chi square revealed there was no significant differences between both groups in sex distribution (p>0.837).

Table (2): Distribution of sex in Group A and B.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>F-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groups</td>
<td>2.607</td>
<td>0.091</td>
</tr>
<tr>
<td>Measuring periods</td>
<td>10.055</td>
<td>0.0001 *</td>
</tr>
<tr>
<td>Interaction</td>
<td>20.827</td>
<td>0.0001 *</td>
</tr>
</tbody>
</table>

*:* Significant at alpha level <0.05.

A- Overall effect:
Statistical analysis using 2 X 2 mixed design MANOVA indicated that there were no significant effects of the tested group (the first independent variable) on the tested dependent variables; platelets count and INR (F=2.607, p=0.09 1). However, there were significant effects of the measuring periods (the second independent variable) on the tested dependent variables (F=10.055, p=0.0001 *). Also, the interaction between the two independent variables was significant, which indicates that the effect of the tested group (first independent variable) on the dependent variables was influenced by the measuring periods (second independent variable) (F=20.827, p=0.0001 *).

B- Multiple pairwise comparison:
1- Platelets count:
   • Within groups:
As presented in (Table 4) and illustrated in Fig. (1), within group's comparison the mean ± SD values of platelets count in the "pre" and "post" tests were 278.56±35.03 and 259.62±38.2 respectively in the control group. Multiple pairwise comparison tests (post hoc tests) revealed that there was no significant difference of platelets count at
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post-treatment in compare to pre-treatment ($p$-value=0.163).

Additionally, the mean ± SD values of platelets count in the "pre" and "post" tests were 275.79 ± 50.21 and 337.92±41.63 respectively in the study group. Multiple pairwise comparison tests (post hoc tests) revealed that there was significant increase of platelets count at post treatment in compare to pre-treatment ($p$-value=0.0001 *).

**Between groups:**

Considering the effect of the tested group (first independent variable) on platelets count, multiple pairwise comparison tests (post hoc tests) revealed that the mean values of the "pre" treatment between both groups showed no significant differences with ($p$=0.886). While, multiple pairwise comparison tests (post hoc tests) revealed that there was significant differences of the mean values of the "post" treatment between both groups with ($p=0.0001 *$) and this significant increase in favor to study group.

### Table (4): Mean ± SD and $p$-values of platelets count pre and post-test at both groups.

<table>
<thead>
<tr>
<th>Platelets count</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>MD</th>
<th>% of change</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>278.56±35.03</td>
<td>259.62±3.82</td>
<td>18.937</td>
<td>6.79↓</td>
<td>0.163</td>
</tr>
<tr>
<td>Study group</td>
<td>275.79±50.21</td>
<td>337.92±41.63</td>
<td>−62.129</td>
<td>22.52↑</td>
<td>0.0001 *</td>
</tr>
<tr>
<td>MD</td>
<td>2.767</td>
<td>−78.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p$-value</td>
<td>0.887</td>
<td>0.0001 *</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*: Significant level is set at alpha level <0.05.

SD : Standard Deviation.
MD : Mean Difference.
$p$-value : Probability value.

2- INR:

**Within groups:**

As presented in (Table 5) and illustrated in Fig. (2), within group's comparison the mean ± SD values of INR in the "pre" and "post" tests were 1.7±0.44 and 1.75±0.46 respectively in the control group. Multiple pairwise comparison tests (post hoc tests) revealed that there was no significant difference of INR at post-treatment in compare to pre-treatment ($p$-value=0.702). Additionally, the mean ± SD values of INR in the "pre" and "post" tests were 1.87±0.49 and 1.24±0.31 respectively in the study group. Multiple pairwise comparison tests (post hoc tests) revealed that there was significant reduction of INR at post-treatment in compare to pre-treatment ($p$-value=0.0001 *).

**Between groups:**

Considering the effect of the tested group (first independent variable) on INR, multiple pairwise comparison tests (post hoc tests) revealed that the mean values of the "pre" treatment between both groups showed no significant differences with ($p=0.421$). Multiple pairwise comparison tests (post hoc tests) revealed that there was significant differences of the mean values of the "post" treatment between both groups with ($p=0.001 *$) and this significant reduction in favor to study group.

### Table (5): Mean ± SD and $p$-values of INR pre and post-test at both groups.

<table>
<thead>
<tr>
<th>INR</th>
<th>Pre-test Mean±SD</th>
<th>Post-test Mean±SD</th>
<th>MD</th>
<th>% of change</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>1.7±0.44</td>
<td>1.75±0.46</td>
<td>−0.049</td>
<td>2.97</td>
<td>0.702</td>
</tr>
<tr>
<td>Study group</td>
<td>1.87±0.49</td>
<td>1.24±0.31</td>
<td>0.627</td>
<td>33.6↓</td>
<td>0.0001 *</td>
</tr>
<tr>
<td>MD</td>
<td>−0.161</td>
<td>0.515</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p$-value</td>
<td>0.421</td>
<td>0.001 *</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*: Significant level is set at alpha level <0.05.

SD: Standard Deviation.
MD: Mean Difference.
$p$-value: Probability value.
Discussion

Recently, there is an increase in the number of studies investigating the biological effects of magnetic fields at the cellular level. This is mainly due to the fact that the daily exposure to magnetic fields constantly increases with the increasing dependence on electricity in our daily lives. Although many studies have been conducted on the effects of magnetic fields on blood cells such as macrophages, neutrophils and lymphocytes [13] few studies investigating the effects of magnetic fields on platelets were found.

The results after one month of exposure to magnetic field revealed that considering the effect of the tested group on platelets count revealed that the mean values of the "pre-treatment between both groups showed no significant differences with \((p=0.886)\) and there was significant differences of the mean values of the "post" treatment between both groups with \((p=0.0001 *)\) and this significant increase in favor to study group (22.52% increase). While considering the effect of the tested group on INR revealed that the mean values of the "pre" treatment between both groups showed no significant differences with \((p=0.421)\) and there were significant differences of the mean values of the "post" treatment between both groups with \((p=0.001 *)\) and this significant reduction in favor to the study group.

The results of the current study were supported by many studies most of them were vitro studies while only two studies were on humans.

A clinical trial of 100 factory workers including welders, computer operators and individuals working in furnace who had at least 5 years work experience and were approximately 25-35 years old were 48 hours exposed to waves per week were studied. The mean platelet count in the treated group with the control group had a 27 percent increase that these increase is statistically significant \((p<0.05)\) [14].

Experiments were conducted using blood from 18 healthy volunteers (8/10, / ) in the age range of 20 to 52. The results showed that the 1-hour, 1mT or 5mT static magnetic field exposures have no effect on platelet count and aggregation [15].

The first study on vitro was 80 male white mice were exposed to two different types of mobile phones (with frequency of 900-1800MHz). The result showed a significant increase of platelet count (increased with prolonged time of exposure) [16].

One of the animal studies concluded that exposing Albino rats to MF with constant power in the range from (1.4-4.7) mW/cm square and frequency of 900MHz for 2 weeks, resulted in significant increase in blood platelets count with value of 67.14% compared to control group [17].

Another trial investigated the effect of EMF (2 mili-tesla intensity and 50Hz frequency) exposure 4h./day, for 30 days on a total of 120 female healthy albino rats resulted in increase in blood platelets count \((p<0.001)\) compared to control group [18].

In this study 48 female Wistar rats exposed to \((0.97mT, 3h./day for 50 days)\) showed a significant increase of the platelets count \((p<0.001)\) compared to the control group [19].

Other trial showed increased platelets count in Albino rats following exposure of EMF of \((1h./day during 30 consecutive days)\) [20].

Adult male Wistar rats were exposed to static magnetic field \((128mT)\) for 1h./5 days/week for 6 weeks showed significant increase of platelet count \((+10%, p<0.05)\) compared to control group [21].

The immediate effects of whole body exposure to 2.450GHz magnetic radiation on hematological parameters on 140 adult Wistar rats showed Platelet count reduced from the control value immediately after exposure then increased gradually after 1, 2, 4 and 8 weeks respectively [22].

In contrast Aweda et al., at 2010 showed decrease of the platelet count, 140 adult Wistar rats were exposure to 2.450GHz Microwave (MW) radiation showed that platelet counts reduced from 300.0 X 10^9/l to 210.0 X 10^9/l immediately after exposure, and did not recover the normal value within the study period [23].

Conclusion:

Exposure to magnetic field in Vivo increases blood and decreases blood viscosity which may be beneficial to patient with deficient blood coagulation.

Acknowledgments:

Authors of this paper are very thankful to a lot of people who have helped them in making the present study possible.

References


تأثير المجال المغناطيسي المتقطع على عدد الصفائح الدموية وعملية التجلط الدموي في الأشخاص الأصحاء

المقدمة: يعرف العلاج بالمجال المغناطيسي الآن في نظر طب القرن الحادي والعشرين أنه كيان علاجي قوي يؤثر على كثير من المشاكل الصحية حتى في حالة فضيل العلاجات التقليدية الأخرى. إنه يوفر وسيلة آمنة، سهلة وغير مخترقة للجسم للعلاج المباشر للكائن الإصابة ومصدر الألم والالتهابات والعلاج العديد من الأمراض. إنه قادر على علاج الكثير من المشاكل الصحية المنتشرة في تأخر إنتاج الكسور وعلاج الألم ومرض التصلب المتعدد ومرض باركنسون.

الهدف: أجريت الدراسة الحالية لتحديد تأثير المجال المغناطيسي المتقطع على عدد الصفائح الدموية وعملية تجلط الدم في الأشخاص الأصحاء.

الأساليب: اشترك في هذه الدراسة عدد 31 من الأشخاص الأصحاء تتراوح أعمارهم بين 25-45 عام وتم اختيارهم من فريق عمل قسم العلاج الطبيعي. تم تشتت كمية هيئة الشرطة بالعجرة حيث كانوا لا يعانون من أي أمراض مزمنة ولم يتم تعرضهم للمجال المغناطيسي المتقطع من قبل. تم تقسيمهم إلى مجموعتين: المجموعة الأولى مكونة من 21 شخص (11 ذكر و12 أنثى) تم تعرضهم للمجال المغناطيسي لمدة شهر بمعدل 3 جلسات في الأسبوع بمجموع 12 جلسة لمدة الجلسة 20 دقيقة، بينما المجموعة الثانية تكونت من 8 أشخاص (4 ذكر و4 أنثى) لم يتعرضوا للمجال المغناطيسي وكانت الجلسة مجرد تطبيق الجهاز بدون تيار (تأثیر خادع).

النتائج: أوضحت النتائج أن التعرض للمجال المغناطيسي المتقطع لفترات طويلة يزيد من عدد الصفائح الدموية ويزيد من معدل التجلط الدموي.