Kinemyography (KMG) Versus Electromyography (EMG) Neuromuscular Monitoring in Pediatric Patients Receiving Rocuronium during General Anesthesia

EMAD ABDEL GHAFFAR, M.D.; SALAH ABDEL FATAH, M.D.; MAGDY A. OMERA, M.D.; HOSSAM M. ATEF, M.D. and MOHAMMED A. ABDEL-AZIZ, M.D.

The Department of Anesthesiology, Faculty of Medicine, Suez Canal University Hospitals, Ismailia, Egypt

Abstract

There are a limited number of studies that compared kinemyography (KMG) and mechanomyography in the clinical practice but few studies compared KMG to electromyography (EMG) either in adults and none in children. This study compared the time course data for rocuronium relaxation measured by KMG to that measured by EMG in children 2-6 years old.

Methods: 24 children ASA I or II of both sexes, aged 2-6 years, scheduled for elective surgery under GA were included in the study. Premed with midazolam 0.3mg/kg orally. Monitoring included ECG, NIBP, pulse oximetry, capnography, anesthetic gas monitor and temperature. NMT monitoring consisted of attaching the pediatric KMG sensor (NMT mechanosensor, for Datex GE, S5) in one hand, while the other hand had a 5 lead EMG (EMG for Datex GE, S5) for simultaneous recording of both modalities.

Anesthesia was induced with fentanyl 2 µg/kg and propofol 2 µg/kg followed by endotracheal intubation. Ventilation was maintained by endtidal isoflurane 1.2% in 50% oxygen/air to maintain endtidal CO₂ 32-35mmHg. After 3 minutes of stable supramaximal stimulation, a train of four stimulus was applied every 15sec. each patient had a single dose of 0.6mg/kg rocuronium. The following parameters were collected (1) Lag time, (2) Onset time, (3) Assessing the recovery period by; train of four (TOF) 0.25, 0.50, 0.75 and 0.90. No top-up doses of rocuronium were given. Statistical analysis was done as appropriate.

Results: There were no statistically significant differences in the lag time, the onset time, TOF 0.25, 0.5, 0.75 and 0.9 ratios using either EMG or KMG. In addition, there was an excellent degree of agreement between EMG and KMG in measuring TOF ratio during both induction and recovery of rocuronium.

Conclusion: KMG showed an excellent degree of agreement with EMG for determination of onset and recovery of a single dose of rocuronium in children. The KMG is easy to use and can guide the clinician in assessing onset and recovery of rocuronium in children.

Key Words: Kinemyography – Neuromuscular transmission (NMT) – Mechanosensor – Electromyography – Neuromuscular monitoring – Rocuronium.

Introduction

TRADITIONALLY, the degree of NMB during and after anesthesia is evaluated by clinical criteria. However, many studies have documented that routine clinical evaluation of recovery of neuromuscular function does not exclude clinically significant residual curarization [1-6].

Electrical nerve stimulation is by far the most commonly used methods in clinical practice. Available methods for objective neuromuscular monitoring is mechanomyography (MMG), EMG, KMG, phonomyography and acceleromyography [7]. MMG has long been regarded as the gold standard of neuromuscular monitoring. However, it has limitations, notably the difficult set-up procedures with special arm boards, and requirement for stable positioning of the arm and bulky force transducers. Furthermore, it cannot be used at muscles other than the adductor pollicis, such as the corrugator supercilii or the orbicularis oculi. It was found that data obtained from EMG didn't differ significantly from that obtained from MMG [8-10]. So EMG has replaced MMG as a standard neuromuscular monitoring in clinical practice [10].

KMG has been available for some years in the form of the NMT-Mechanosensor integrated in the Datex anesthetic machine. Some studies have shown that its agreement with MMG for scientific purposes might be limited with unacceptably wide limits of agreement [11,12] in clinical circumstances.
Kinemyography (KMG) Versus Electromyography (EMG)

It can be used reasonably well to detect the time to tracheal intubation and recovery of NMB. However, the device can only be applied to measure NMB at the adductor pollicis muscle [12-16].

There are a limited number of studies compared KMG and EMG in clinical practice, but none of these studies compared these two devices in children, or evaluated the effect of the type of the muscle relaxant on data obtained by KMG versus EMG.

This study was performed to determine whether the data obtained from KMG can be interchanged with data obtained from EMG in children during general anesthesia using rocuronium as a muscle relaxant.

Patients and Methods

This study was a randomized, comparative clinical trial carried out on 24 pediatric patients of both sexes undergoing elective surgery under general anesthesia in Suez Canal University Hospital in the routine surgical lists during the period from November 2008 to July 2009.

Inclusion criteria:

Patients aged 2-6 years of both sexes with normal body mass index (BMI) (18-25kg/m²) who undergoing body surface operations, that don't require intense muscle relaxation.

Exclusion criteria:

Patients with any disorders of the cardiovascular, hepatic, renal, small joint arthritis or neuromuscular systems known from history or clinical examination and investigations, patients on medication known to interact with neuromuscular blocking drugs e.g. Antibiotics (aminoglycosides, tetracyclines), anti-anticonvulsants or oral muscle relaxants, arrhythmias (calcium channel blockers, quinidine) and magnesium sulfate patients in whom difficult intubation was expected, and patients with major operations, upper limb or thoracic operations were excluded from the study.

Methods:

During the preoperative visit, the study and the techniques were explained to the parents and written informed consent was taken from the parents.

The patient's age, sex, BMI and ASA status and type of surgery were recorded. Preoperative assessment was carried out in the pre-operative outpatient anesthesia clinic at the Suez Canal University Hospital, included: Medical history, General examination, Anesthetic assessment. All patients were premedicated using 0.5 µg/kg midazolam per OS 30-60 minutes preoperatively in the preoperative holding area. In the operating theater; Monitoring equipments (Datex-Ohmeda A/S 5TM) was attached to the patient, including 3 leads ECG, automatic non-invasive blood pressure, pulse oximetry; anesthetic gas monitoring and temperature probe after induction of anesthesia. Both arms were comfortably positioned on arm boards. The area overlying the ulnar nerve at the wrist, where the electrodes to be placed, is cleaned by alcohol swab to ensure adequate contact. The stimulating electrodes (Ag/AgCl ECG electrodes for children) were stuck to the skin, which had been cleaned. The electromyogram was attached to one hand, while the kinetomyogram was attached to the other hand for simultaneous monitoring. The stimulating electrodes were placed over the ulnar nerve, which is found directly radially from the tendon of the flexor carpi ulnaris muscle as it ends in the pisiform bone of the hand. The NMT mechano-sensor consists of two quick-fit malleable plastic semicircular rings for the thumb and index finger with an interconnecting bending strip. The piezoelectric sensor pad, embedded in the bending strip, lies over the metacarpophalangeal joint of the thumb at the angle between the index finger and thumb. It was aligned with the ideal plane of the opposition movement of the thumb to the index finger. A narrow adhesive tape was used to fix the middle portion of the strip in place. The ring over the thumb was also tapped. This should not interfere with the free thumb movement. The electromyogram electrodes were placed for stimulation of the ulnar nerve and for recording of the compound action potential from adductor pollicis previs muscle, using a second Datex-Ohmeda A/S 5 monit. Preoxygenation with 100% oxygen for 3 minutes. Induction of anesthesia with fentanyl 2 µg/kg and propofol 2 µg/kg followed by endo-tracheal intubation. Anesthesia was maintained by isoflurane 1.2%. Ventilation by 50% oxygen in air, ventilation was adjusted to maintain end-tidal CO₂ in the range of 35-40mmHg. Patients was warmed to keep the temperature of both hands constant at ≥32°C and the core temperature ≥35°C by means of warmed IV fluids and warming blankets. Readings of the heart rate (HR), arterial blood pressure (ABP), oxygen saturation (SpO₂), temperature (body core temperature through nasopharyngeal probe and skin temperature) and neuromuscular transmission sensors were continually displayed on the monitors. Neuromuscular monitoring was carried out by supramaximal TOF stimuli up to 80MA from Datex-Ohmeda NMT Sensor (2Hz/0.5s; pulse width 0.2ms) every 10 seconds to stimulate the ulnar...
nerve via surface electrodes. After a stable baseline period for at least 3 minutes, the 24 patients received 0.6 µg/kg rocuronium (2xED95). The drug was prepared in a fixed volume of 5ml. The following parameters were collected and compared:

1- Lag time: Time from start of muscle relaxant administration until the first measurable block TOF ratio 90%.

2- Onset time: Time from start of muscle relaxant administration until maximal neuromuscular block.

Assessing the recovery period by:

3- TOF 0.25 = Time to reach a TOF ratio of 25%.
4- TOF 0.50 = Time to reach a TOF ratio of 50%.
5- TOF 0.75 = Time to reach a TOF ratio of 75%.
6- TOF 0.90 = Time to reach a TOF ratio of 90%.
7- Spontaneous recovery index (dur TOF 0.25-TOF 0.9).

No top-up doses of muscle relaxants were given. Patients were allowed to recover spontaneously from the neuromuscular block until a stable recovery signal occurred, defined as TOF ratio ≥ 0.9 with response variation ≤ 5% for 2min. At the end of surgery inhalational anesthesia was omitted, patient ventilated with 50% oxygen in air and the patient was extubated when TOF ratio ≥ 0.9. Any unwanted events were recorded. At the post anesthesia care unit, the patient was monitored for heart rate, blood pressure, oxygen saturation, conscious level and activity.

Results

Demographic data:

The mean age of the patients was 3.6 ± 1.01 years. Regarding the weight of the patients, the mean weight of the patients was 14.83 ± 2.51kg. Regarding sex distribution, the frequency of male patients was 14 (58.33%) and the frequency of female patients was 10 (41.67%). As regards the ASA state of the patients, ASA I patients represented about 67%, while ASA II patients represented about 33%.

Pharmacodynamic time variables using EMG and KMG in both studied groups (in seconds):

There was no statistical difference between both groups using EMG or KMG (Table 1). This was confirmed by a strong degree of agreement between KMG and EMG in both groups using a correlation coefficient test.

Onset phase:

After rocuronium administration, the TOF ratio of both monitors started to decrease simultaneously. There was no significant difference in the lag and onset times measured by the two monitors. Full block was reached in all patients independent of the monitoring technique.

Recovery phase:

Both monitors detected the start of recovery from NMB as well as TOF 0.25, 0.50, 0.75 and 0.90 with excellent limits of agreement (Table 1).

During recovery from NMB, the plotting of difference and mean of the two monitors in TOF 0.90 showed in Fig. (1). The correlation coefficient for the strength of agreement between both monitors was 0.980 (Table 1).

The plotting of difference and mean of the two monitors in TOF 0.75 showed in Fig. (2). The correlation coefficient for the strength of agreement between both monitors was 0.964 (Table 1).

The plotting of difference and mean of the two monitors in TOF 0.50 showed in Fig. (3). The correlation coefficient for the strength of agreement between both monitors was 0.927 (Table 1).

The plotting of difference and mean of the two monitors in TOF 0.25 showed in Fig. (4). The correlation coefficient for the strength of agreement between both monitors was 0.986 (Table 1).

Table (1): Pharmacodynamic time variables (in seconds) using EMG and KMG in both studied groups.

<table>
<thead>
<tr>
<th></th>
<th>EMG Mean</th>
<th>EMG SD</th>
<th>KMG Mean</th>
<th>KMG SD</th>
<th>Mean difference</th>
<th>Mean (EMG+KMG)/2</th>
<th>t</th>
<th>p-value</th>
<th>αc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag time</td>
<td>39.17</td>
<td>8.81</td>
<td>42.46</td>
<td>8.93</td>
<td>-3.29</td>
<td>40.815</td>
<td>1.29</td>
<td>0.20</td>
<td>0.856</td>
</tr>
<tr>
<td>Onset time</td>
<td>101.67</td>
<td>20.57</td>
<td>105.00</td>
<td>22.07</td>
<td>-3.33</td>
<td>103.335</td>
<td>0.54</td>
<td>0.594</td>
<td>0.977</td>
</tr>
<tr>
<td>TOF 0.25</td>
<td>25.42</td>
<td>3.43</td>
<td>25.83</td>
<td>3.47</td>
<td>-0.41</td>
<td>25.625</td>
<td>0.40</td>
<td>0.69</td>
<td>0.986</td>
</tr>
<tr>
<td>TOF 0.50</td>
<td>30.46</td>
<td>3.86</td>
<td>31.04</td>
<td>4.05</td>
<td>-0.58</td>
<td>30.75</td>
<td>0.47</td>
<td>0.64</td>
<td>0.927</td>
</tr>
<tr>
<td>TOF 0.75</td>
<td>35.92</td>
<td>3.57</td>
<td>36.87</td>
<td>3.69</td>
<td>-0.95</td>
<td>36.395</td>
<td>0.93</td>
<td>0.36</td>
<td>0.964</td>
</tr>
<tr>
<td>TOF 0.90</td>
<td>41.88</td>
<td>4.59</td>
<td>42.62</td>
<td>4.85</td>
<td>-0.74</td>
<td>42.25</td>
<td>0.54</td>
<td>0.59</td>
<td>0.980</td>
</tr>
<tr>
<td>Dur TOF 0.25-TOF 0.9</td>
<td>16.45</td>
<td>1.5</td>
<td>16.79</td>
<td>1.42</td>
<td>-0.34</td>
<td>16.62</td>
<td>1.24</td>
<td>0.53</td>
<td>0.986</td>
</tr>
</tbody>
</table>

EMG = Electromyography.
KMG = Kinemyography Insignificant p-value >0.05.
αc = Correlation coefficient description for strength of agreement.
<0.6 = Unsatisfactory. 0.6 to 0.9 = Satisfactory. 0.91 to 1 = Excellent.
Discussion

There are a limited number of studies that compared KMG and EMG in the clinical practice, but none of these studies compared these two devices in children, or evaluated the effect of the type of the muscle relaxant on data obtained by KMG versus EMG.

In this study, the lag time for rocuronium was 39.2±8.8 seconds when monitored with EMG and 42.5±8.9 seconds when monitored with KMG, with no statistical difference between the two monitors in detecting the lag time of rocuronium. In addition, there is a strong degree of agreement between KMG and EMG in detecting the lag time of rocuronium using correlation coefficient test (αc=0.85).

This finding is in accordance with the results of Fuchs-Buder and Tassonyi [17] for assessing the intubating condition and the time course of rocuronium in children with a mean age of 5 years. They found that the lag time of rocuronium 0.6 µg/kg was 37±12 sec.

In a further study carried out by Wick et al., [18] when evaluating the onset and duration of rocuronium-induced neuromuscular blockade in patients with Duchene muscular dystrophy, the median lag time of rocuronium 0.6 µg/kg was 45 seconds with a range of 30-60 seconds in the control group.

In another study performed by Hemmerling et al., [19] the authors compared 0.6 µg/kg rocuronium versus 0.2 µg/kg mivacurium. They recorded the...
lag time of rocuronium was 46±18 (30-80) sec in 40 adult patients. However, the difference in the lag time between the present study and the previous studies may be attributed to the difference in age of patients studied in their groups.

This was demonstrated in a study carried out by Taivainen et al., [20] assessed the neuromuscular block of rocuronium in infants, children and adults. They found that the onset time of the first dose of rocuronium was shorter in children than in infants or adults. The short onset time of rocuronium in children may be due to a more rapid distribution of rocuronium in children than in infants. Therefore, the peak concentration and maximal blocking effect of rocuronium as well as shorter onset time are produced sooner in children than in infants and adults.

When comparing the EMG and KMG in detecting the lag time of rocuronium, there was no statistical difference between the two monitors with \( p=0.2 \). In addition, there was a strong degree of agreement between KMG and EMG in detecting the lag time of rocuronium using the correlation coefficient.

These findings are supported by results of Dahaba et al., [13] who compared the neuromuscular block of 0.6 \( \mu \)g/kg rocuronium (twice the 95% effective dose) monitored by the M-NMT with that monitored by the Relaxometer® mechanomyograph (MMG). They found that the two monitors simultaneously detected the lag time with the \( p \) value= 0.7 and the bias (the mean of the difference between the two monitors) = 0.1 with upper limits of agreement = 0.05 and lower limits of agreement = (0.05).

The onset time for rocuronium was 101.7 \( \pm \)20.6 seconds when monitored with EMG, and 105 \( \pm \)22 seconds when monitored with KMG, with no statistical difference between the two monitors in detecting the onset time of rocuronium (\( p=0.56 \)). Additionally, there is a strong degree of agreement between KMG and EMG in detecting the onset time of rocuronium where the correlation coefficient (\( \alpha \cdot c \)) was 0.97.

Our results are supported by results of Dahaba et al., [13] where the onset time of rocuronium 0.6 \( \mu \)g/kg was 90\( \pm \)18 Sec. Also the study done by Wick et al., [18] when compared the onset and duration of rocuronium-induced neuromuscular blockade in patients with Duchene muscular dystrophy, they found that the median onset time of rocuronium 0.6 \( \mu \)g/kg was 90Sec with the range of 60-195Sec in the control group.

However, the results of Hammerling et al., [19] in comparing succinylcholine with two doses of rocuronium, the onset time of rocuronium 0.6 \( \mu \)g/kg was 145\( \pm \)48 Sec when monitored at adductor pollicis.

In addition, Fuchs-Buder and Tassonyi [17] during assessment of the intubating conditions and the time course of rocuronium in children with a mean age of 5 years, the onset time of rocuronium 0.6 \( \mu \)g/kg was 193\( \pm \)47Sec. The anesthesia was induced with 10 \( \mu \)g/kg alfentanil and 5 \( \mu \)g/kg thiopentone and maintained with isoflurane 1%.

Furthermore, Kim et al., [21] studied the time course of neuromuscular effects of rocuronium during desflurane anesthesia in adult patients with or without renal failure, the onset time of rocuronium 0.6 \( \mu \)g/kg was 192\( \pm \)72Sec in normal patients. In their work, the neuromuscular transmission was monitored by acceleromyography using TOF-Watch (Organon Ltd, Dublin, Ireland) equipment.

The longer onset time in these studies compared with that in the present study may be explained by the use of different anesthetic technique, use of different methods of neuromuscular monitoring and difference in age groups of the patients in some of these studies.

In the current study, the time to reach a TOF ratio of 25% for rocuronium was 25.4 \( \pm \)3.4 minutes when monitored with EMG, and 25.8 \( \pm \)3.5 minutes when monitored with KMG, with no statistical difference between the two monitors in detecting the time to reach a TOF ratio of 25% of rocuronium (\( p=0.69 \)).

Our result is supported by the results of Wick et al., [18] where the median time to reach a TOF ratio of 25% for rocuronium 0.6 \( \mu \)g/kg was 26.3min with a range of 14-34 minutes.

However, Hans et al., [22] found that the time from rocuronium 0.6 \( \mu \)g/kg injection to the recovery of a TOFR of 0.25 was 36.1 \( \pm \)15.1 minutes.

In this study the time to reach a TOF ratio of 50% for rocuronium was 30.5 \( \pm \)3.9 minutes when monitored with EMG, and 31 \( \pm \)4.1 minutes when monitored with KMG, with no statistical difference between the two monitors in detecting the time to reach a TOF ratio of 50% of rocuronium (\( p=0.64 \)).

These findings agree with the results of Trager et al., [23], where they recorded a satisfactory degree of agreement between KMG and MMG in detecting the recovery period till TOF 50% of mivacurium 0.2 \( \mu \)g/kg where the correlation coefficient was 0.8604.
However, Hans et al., [22] in studying the recovery from neuromuscular block after an intubating dose of cisatracurium and rocuronium in adult patients found that the time from 0.1 \( \mu g/kg \) cisatracurium injection to the recovery of a TOF ratio of 0.5 was 61 ± 6.2 minutes. In their study, anesthesia was induced with IV sufentanil 0.15 \( \mu g/kg \), ketamine 0.15 \( \mu g/kg \) and propofol 2 \( \mu g/kg \) and maintained with sevoflurane (1.5-2% end tidal) and 60% nitrous oxide in oxygen. Neuromuscular transmission was monitored at the wrist by acceleromyography using the TOF-Guard monitor.

In the current study, the time to reach a TOF ratio 75% for rocuronium was 35.9 ± 3.6 minutes when monitored with EMG, and 36.9 ± 3.7 minutes when monitored with KMG, with no statistical difference between the two monitors in detecting the time to reach a TOF ratio 0.75 of rocuronium (\( p=0.36 \)).

These findings are supported by the results of Jellish et al., [24] where the median recovery time in the TOF ratio in 0.75 was 31.4 (21.5-51) min after bolus injection of 0.6 \( \mu g/kg \) rocuronium.

However, Carroll et al., [25] found that the time from rocuronium 0.6 \( \mu g/kg \) injection to the recovery of a TOFR of 0.8 was 50 (28.4-76.1).

Also, Hemmerling et al., [19] in comparison of succinylcholine with two doses of rocuronium in adults found that recovery to TOF ratio to 0.75 of rocuronium 0.6 \( \mu g/kg \) was 54 ± 18 min. In their study, the anesthesia was maintained with propofol and remifentanil and the neuromuscular transmission was monitored with acceleromyogram.

Also, Kim et al., [21] studied the time course of neuromuscular effects of rocuronium during desflurane anesthesia in patients with or without renal failure, the recovery to TOF ratio of 0.7 of rocuronium 0.6 \( \mu g/kg \) was 68.7 ± 15.5 min in normal patients. In their study, the neuromuscular transmission was monitored by acceleromyography using TOF-Watch (Organon Ltd, Dublin, Ireland) equipment.

Moreover, Maybauer [26] in evaluating the incidence and duration of residual paralysis at the end of surgery after multiple administrations of cisatracurium and rocuronium, the recovery time of T4/T1 in 0.7 was 58 ± 28 min following 0.6 \( \mu g/kg \) rocuronium.

In the current study, the time to reach a TOF ratio of 0.9 for rocuronium was 41.9 ± 4.6 minutes when monitored with EMG, and 42.6 ± 4.6 minutes when monitored with KMG, with no statistical difference between the two monitors in detecting the time to reach a TOF ratio 0.9 of rocuronium (\( p=0.59 \)).

These findings are supported by results of Dahaba et al., [27] in comparing the neuromuscular transmission monitor compressomyograph with the mechanomyograph, found that the recovery time of rocuronium 0.6 \( \mu g/kg \) to T4/T1 to 0.9 was 43.3 ± 10.0 minutes when measured with mechanomyograph and 43.1 ± 10.3 minutes when measured with compressomyograph.

Also, Dahaba et al., [13] compared the neuromuscular block time course of 0.6 \( \mu g/kg \) rocuronium using the M-NMT versus the Relaxometer® mechanomyograph (MMG). They found that the recovery time of T4/T1 in 0.9 was 49.4 ± 8.1 min.

In the study of Wick et al., [18] that compared the onset and duration of rocuronium-induced neuromuscular blockade in patients with Duchenne muscular dystrophy, the median time to reach a TOF ratio 0.9 of rocuronium 0.6 \( \mu g/kg \) was 38.5 with a range of 22-55 minutes in the control group.

However, Maybauer et al., [26] during studying the incidence and duration of residual paralysis at the end of surgery after multiple administrations of cisatracurium and rocuronium, the recovery time of T4/T1 in 0.9 was 63 ± 29 min following 0.6 \( \mu g/kg \) of rocuronium.

References


7- MOHAMED NAGUIB and CYNTHIA A. LIEN.: Pharmacology of Muscle Relaxants and Their Antagonists.


الملخص العربي

تم إجراء هذه الدراسة للمقارنة بين كل من جهاز استشعار ميكانيكية العضلات و جهاز استشعار كهربائية العضلات في الأطفال الذين يتقنون رياضات ركوب الدراجات أثناء التدريبات البدنية، وشملت هذه الدراسة 24 مريضًا من كل الجنسين تتراوح أعمارهم بين 6-2 سنوات، مع ون أقصى 20 كيلوجرامًا. أثناء إجراء عملية جراحية اختيارية تحت التدريبات في مستشفى جامعة قناة السويس، أُطلق روتونتينوم (20 مريضًا)

تلقى روتونتينوم 0.5 مغ/كم².

وقد تم مقارنة المعاملات التالية:

- نسبة الـ TOF.

1. بداية الوقت: الوقت الذي يلتقي مع بداية إعطاء العقار المريخي للعضلات حتى يتم إعطاء العضلات إلى الدرجة القصوى.

تقدير فترة الاسترداد:

TOF = TOF × 0.25
TOF = TOF × 0.5
TOF = TOF × 0.75
TOF = TOF × 0.9

2. الوقت لتصل إلى الدرجة القصوى.

وكانت نتائج الدراسة كالتالي:

لا يوجد أي فرق إحصائي في وقت الانتهاء بين جهاز استشعار ميكانيكية العضلات و جهاز استشعار كهربائية العضلات.

- لم يكن هناك أي فرق إحصائي في وقت الانتهاء بين جهاز استشعار ميكانيكية العضلات و جهاز استشعار كهربائية العضلات.

- لم يكن هناك أي فرق إحصائي في وقت الانتهاء بين جهاز استشعار ميكانيكية العضلات و جهاز استشعار كهربائية العضلات.

- لم يكن هناك أي فرق إحصائي في وقت الانتهاء بين جهاز استشعار ميكانيكية العضلات و جهاز استشعار كهربائية العضلات.

- لم يكن هناك أي فرق إحصائي في وقت الانتهاء بين جهاز استشعار ميكانيكية العضلات و جهاز استشعار كهربائية العضلات.

- هناك نسبة مالفة من الانتفاخ بين جهاز استشعار ميكانيكية العضلات و جهاز استشعار كهربائية العضلات، في قياس نسبة ارتفاع وانفعال العضلات.

Kinemyography (KMG) Versus Electromyography (EMG)