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ORIGINAL

RELIABILITY OF TENSIOMIOGRAPHY (TMG) AS A MUSCLE ASSESSMENT TOOL

FIABILIDAD DE LA TENSIOMIOGRAFÍA (TMG) COMO HERRAMIENTA DE VALORACIÓN MUSCULAR

Benítez Jiménez, A.[1]; Fernández Roldán, K.[2]; Montero Doblas, J. M.[3] & Romacho Castro, J. A.[4]

[1] Departamento Educación Física y Deporte, Universidad de Sevilla, España, abeji_88@hotmail.com
[2] Departamento Educación Física y Deporte, Universidad de Sevilla, España, kevferrol@gmail.com
[3] Departamento Educación Física y Deporte, Universidad de Sevilla, España, jmmontero7@gmail.com
[4] Departamento Educación Física y Deporte, Universidad de Sevilla, España, jromachocastro@gmail.com

Spanish-English translator: Cristina Alba Carrasco calbcar@gmail.com

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ABSTRACT

Tensiomyography (TMG) is an innovative non-invasive technique designed to evaluate the characteristics of muscle contraction. The aim of this study is to test the reliability of TMG as a measurement of contractile properties of the rectus femoris and medial gastrocnemius.

TMG was used to measure the muscle belly displacement in response to an electrical stimulus among 32 individuals. The parameters to be measured were: maximal muscular displacement (Dm), delay time (Td), contraction time (Tc), sustain contraction time (Ts), and relaxation time (Tr). After the analysis of intra class correlation coefficient (ICC), there was high correlation between the parameters of the rectus femoris and medial gastrocnemius, except the medial gastrocnemius Tr.

According to the results we can conclude that TMG is a reliable method as muscle assessment tool, even though the protocol is essential, because it produces differences on the muscle response, as happened in our case regarding other researches.

KEYWORDS: Tensiomyography, reliability, rectus femoris, medial gastrocnemius.

RESUMEN

La tensiomiografía (TMG) es una innovadora técnica creada para evaluar las características de la contracción muscular de forma no invasiva. El objetivo del presente estudio es comprobar la fiabilidad de la TMG como método de valoración muscular en el recto femoral (RF) y el gastrocnemio medial (GM).

La TMG se utilizó para medir el desplazamiento del vientre muscular tras la aplicación de un estímulo eléctrico en 32 sujetos. Los parámetros medidos fueron: desplazamiento muscular máximo (Dm), tiempo de reacción (Td), tiempo de contracción (Tc), tiempo de mantenimiento de la contracción (Ts) y tiempo de relajación (Tr). Los resultados mostraron alta correlación en los parámetros del RF y del GM, exceptuando el Tr del GM, lo que demuestra que la TMG es un método fiable de valoración muscular.

En base a los resultados obtenidos podemos concluir que la TMG es un método fiable de valoración muscular, si bien el protocolo es fundamental, porque produce diferencias en la respuesta muscular, como ocurrió en nuestro caso respecto a otras investigaciones.

PALABRAS CLAVE: Tensiomiografía, fiabilidad, recto femoral, gastrocnemio medial.

INTRODUCTION

The muscle response has been studied for long years using numerous techniques including nuclear magnetic resonance, electromyographic activity and invasive methods such as biopsies in order to analyze the relation between contractile and histological properties of muscles (Herber et al., 2008).

During the 90s, tensiomyography (TMG) comes out. It was an innovative technique developed by the Professor Valenčič and it started to be used ten years ago for evaluating the athletes (Rodríguez-Matoso et al., 2010). It was created as a non-invasive method of evaluation used for assessing the contractile capacity of superficial muscles (Dahmane et al., 2000); Rodríguez-Matoso et al., 2010). It measures the maximal radial displacement in the muscle belly when a contraction is generated by an electrical external stimulus (Valenčič et al., 2001; Tous-Fajardo et al., 2010; Rodríguez-Matoso et al., 2010). In other words, when inducting this stimulus, the muscle belly undergoes geometric changes (radial transverse deformation) (Rodríguez-Matoso et al., 2010), that are measured by a digital transducer (sensor tip) which presses on skin over the muscle (Tous-Fajardo et al., 2010). As a consequence of the muscular response to that stimulus, TMG offers information about different parameters (Figure 1): Maximal radial displacement (Dm), delay time (Td), contraction time (Tc), sustain contraction time (Ts) and relaxation time (Tr) (Križaj, Šimunič y Žagar, 2008; García Manso et al., 2009; García Manso et al., 2010; Tous-Fajardo et al., 2010).

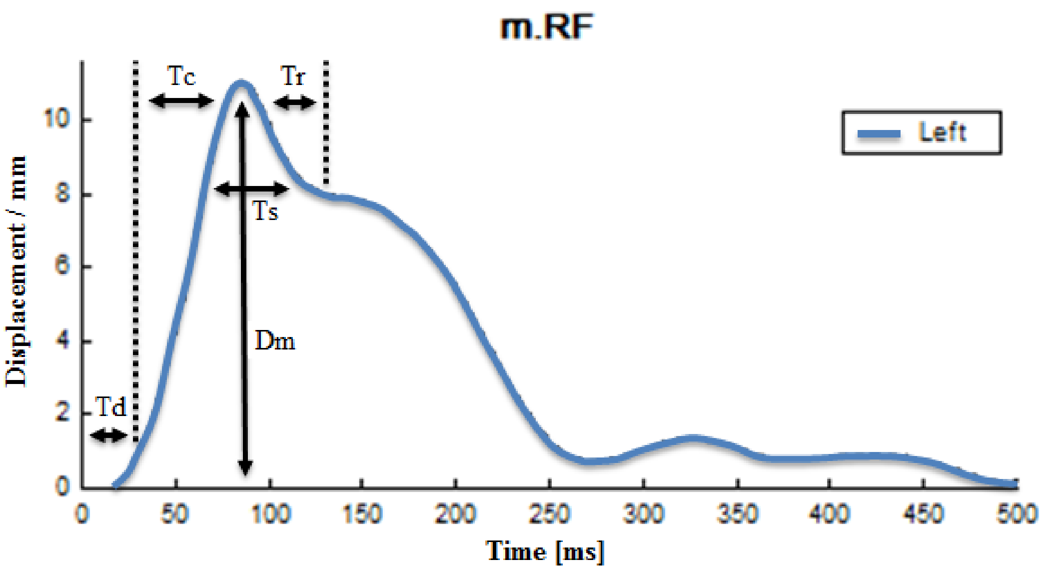

Figure 1. Measurement parameters of TMG. García Manso et al.

As seen above, there are large possibilities of implementing this method. As it is a non-invasive technique, its implementation is crucial in the sport scene when detecting muscle fatigue caused by training, as long as muscle imbalances, not only in the sport performance scene but also in other fields such as sanitary, physical therapy and injury rehabilitation (Dahmane et al., 2005; García Manso et al., 2010; Tous-Fajardo et al., 2010). However, its analysis can be affected by several aspects, such as, the position of the sensor that transmits the electrical stimulus, or the correct layout of electrodes that transmit this stimulus throughout the skin (Tous-Fajardo et al., 2010). For this reason, and, as suggested by the authors Gracía Manso et al. (2009-2010) and Rodríguez Matoso et al. (2010), it is necessary to apply the protocol precisely and accurately when measuring in order not to provoke changes in the results that may lead to misinterpretations. On the other hand, the reliability of the obtained measurements by TMG has not been deeply evaluated (Križaj et al., 2008; Tous-Fajardo et al., 2010) and its reproducibility in different groups has not been determined.

Thus, the aim of this study is to test the reliability of the TMG as a muscle assessment method, in particular of the rectus femoris and medial gastrocnemius.

MATERIAL AND METHODS

Subjects

Thirty two individuals (26 men and 6 women; average ± SD: age 22.41 ± 1.85 years; height 174.07 ± 7.94 cm; body mass 72.40 ± 10.01 kg), with no history of neurological nor muscle diseases, participated in the study on a voluntary basis. All of them were active individuals (they got an average time of 15 hours a week of physical activity) and they signed written consent forms for their participation after being informed of the regular protocol and the potential risks associated with this study.

Variables

The parameters that TMG offers, as described by Rodríguez Matoso et al. (2010,) are: Dm (maximal displacement of the radial muscle belly expressed in millimeters), Td (the time that the muscle structure takes for reaching the 10% of the total displacement), Tc (the time that takes since the reaction time has finished until the 90% of the maximum deformation), Ts (estimated time of during contraction) and Tr (time of muscle relaxation).

For measuring the muscle displacement, a highly accurate mechanic sensor (GK 40, Panoptik d.o.o., Ljubljana, Slovenia) was aligned perpendicularly to the muscle belly. In order to provoke a muscle contraction, an electrical impulse was applied through a TMG-S1 stimulating (EMF-Furlan and Co. d.o.o., Ljubljana, Slovenia) which was connected to a laptop that initiates the electrical signal. The electrical stimulus was transmitted to the muscle belly through two electrodes (Compex Medical SA, Ecublens, Switzerland) symmetrically placed 5 cm distal and 2,5 cm proximal to the edge of the sensor (Tous-Fajardo et al., 2010).

PROCEDURE

The tests were undertaken in the left leg's rectus femoris muscle (RF) and in the right leg's medial gastrocnemius. The choice of both responds the intention of knowing and comparing the answer given by a very explosive muscle group (RF) to another group not so explosive to a great extent (GM). Moreover, the changing position of the tested legs is due to the comfort of the subjects. Besides, it offers us higher precision when placing the equipment. The position of the individuals during the test must allow a relaxing position of the muscles. For this end, each individual must lie on an examining table on a supine position for testing the RF, and after, change into a prone position for testing the GM. In both cases, a cushion was placed in order to ease the optimal angle of flexion for relaxing the muscles (Figure 2).

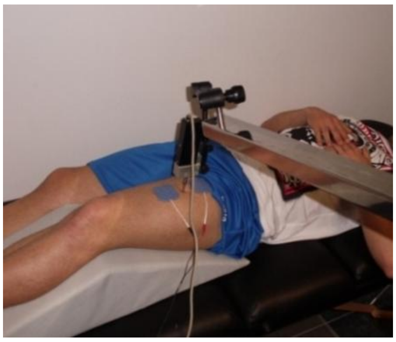

Figure 2. Individual position during RF assesment.

Each individual underwent two consecutive tests in each group of muscles. For locating the muscle to be measured, the individuals were asked to provoke a voluntary contraction and then both electrodes were placed 5 cm distal from each other. Such distance was previously marked with a dermatological pen in order to replicate the positioning on the subsequent re-test used for reliability measures.After that, the TMG sensor was placed at the midpoint between the distal and the proximal electrode (2,5 cm) and it pressed the muscle 1,5 cm on a perpendicular axis (previously marked with a dermal pen).

With the purpose of provoking a contraction, a bipolar electric discharge starts from initial amplitude of 50 mA. The amplitude of the alternating current was increased gradually every 10 seconds for trying to reduce the fatigue and the empowerment effects (Tous-Fajardo et al., 2010). The power increased 10 mA, until reaching the highest stimulation threshold that this device is able to: 110 mA. The power was increased also until muscle displacement (Dm) was noticed but it did not enlarge after two stimulations. Among both tests of the same muscle there was a three minutes interval so as the muscle undertakes muscle fatigue produced by the electrical stimulus and assuring, therefore, that both measurements met full muscle availability.

To summarize, the RF was tested in each individual regarding an interval of ten seconds between every electrical stimulus and a three minutes interval between both measurements. Afterwards, the GM was tested by following the procedure mentioned above.

Statistical analysis

The data provided was analyzed using the statistical package SPSS version 15.0. In order to contrast the reliability of TMG, the intra class correlation coefficient (ICC) of all the variables described above were rated. An ICC score superior to 0, 8 between several TMG parameters was considered reliable, as Tous-Fajardo et al. (2010) had stated. Descriptive values as long as central and spreading trends were analyzed.

RESULTS

The reliability of contractile parameters among both measurements was good or very good for both muscles except the Tr parameter in test of the GM, which proved an ICC inferior value (0.429) following the Sánchez Fernández et al. (2005) scale (figure 3). The parameters with a higher ICC in both muscles were: radial displacement (0.94-0.98) and contraction time (0.92-0.93).

ICC Value	Concordance
> 0,90	Very good
0,71-0,90	Good
0,51-0,70	Moderate
0,31-0,50	Mediocre
□0,30	Bad or null

Figure 3. Assessment of the concordance regarding the intra class correlation coefficient (ICC). Sánchez Fernánder P et al., (2005). Reliability of the measurement tools in the sanitary field.

Table 1 shows the results from the ICC analysis for each muscular performance variables analyzed in the RF. A high reliability in Tc and Dm (ICC > 0.922) was noticed, whereas the rest of the parameters (Ts, Tr and Td) kept good levels of correlation (o.788-0.794) that were similar between them and lower than the previous ones. For the Ts, Tr and Td variables, we could notice lower ICC values far from the media (DS 0.565; 0.573 y 0.618 in that order).

Regarding the GM variables, the reliability was very high when it comes for Tc, Td and Dm (ICC >0.91), whereas, the Ts variable show level of correlation was inferior (0.810) to the previous ones. Besides, there were no important ICC levels found in the Tr (0.062) (Table 2).

Table 1. Intra class correlation analysis in the Rectus Femoris.

		ICC (95%)	DS	Sig
RECTUS FEMORIS	**Tc**	0,922	0,840-0,962	0,000
	Ts	0,788	0,565-0,896	0,000
	Tr	0,792	0,573-0,898	0,000
	Td	0,794	0,618-0,894	0,000
	Dm	0,941	0,878-0,971	0,000

Tc: contraction time; Ts: sustain time; Tr: relaxation time; Td: delay time; Dm: maximal displacement; ICC: intra class correlation coefficient; DS: Standard deviation

Table 2. Intra class correlation analysis in the Medial Gastrocnemius.

		ICC (95%)	DS	Sig
MEDIAL GASTROCNEMIUS	**Tc**	0,928	0,852-0,965	0,000
	Ts	0,810	0,610-0,907	0,000
	Tr	0,429	-0,170-0,721	0,062
	Td	0,913	0,821-0,957	0,000
	Dm	0,981	0,961-0,991	0,000

Tc: contraction time; Ts: sustain time; Tr: relaxation time; Td: delay time; Dm: maximal displacement; ICC: intra class correlation coefficient; DS: Standard deviation

DISCUSSION

The aim of the present study was to prove the reliability of TMG as a muscle assessment tool in the rectus femoris muscle and medial gastrocnemius. These muscles were selected because of the characteristics of its fibers. Since the RF is a fast muscle and GM is a less explosive muscle (Rodriguez-Matoso et al., 2012), the reliability of this tool can be tested and compared when evaluating different muscle morphologies and performances.

So far, few researches have tested the reliability of TMG parameters (Križaj et al., 2008; Tous-Fajardo et al., 2010). During the first one, (Križaj et al., 2008) its reliability was tested from 30 consecutive measurements on the biceps femoris that showed high levels of correlation between measurements (ICC ranged 0.86-0.98). The present study reveals similar results (ICC ranged 0.78-0.94), although Tr and Ts results were inferior, probably because they are bigger muscle groups.

Along the same lines, Tous-Fajardo et al., (2010) evaluated the reliability of this tool among different testers and the outcoming results were, once again, very positive when using this technique for measuring contractile parameters of the interior rectus. Another recent study analyzed the reproducibility of this tool for testing the contractile properties of the muscle regardless the sensor position (Rodríguez Matoso et al., 2010). In that study, a measurement on the RF was implemented and the correlation coefficient was high for the measurements taken in three different positions of the muscle: one in the midpoint and other two 2 cm separated from the midpoint. The Cronbach's alpha coefficients obtained were: 0.970, 0.920, 0.897, 0.976 and 0.984 for Tc, Dm, Td, Ts y Tr (Rodríguez Matoso et al., 2010).

The results of our research correspond to the studies previously mentioned; there are small methodological differences though, so we need to be cautious when comparing the results. In any case, the ICC of the TMG parameters ranges between 0.78 and 0.94 when measuring the RF. The Dm parameter obtained the highest degree of reliability (0.94). Dm and Tc are the parameters that reveal a highest value of reliability, as happened in the study of Tous-Fajardo et al. (2010).

In this regard, it is important to highlight that Dm parameter, according to several authors, may show the most useful data during the testing of contractile properties of muscles through TMG (Dahmane et al., 2001, 2005; Križaj et al., 2008; Tous-Fajardo et al., 2010). Moreover, it correlates positively the muscle electrical activation and it is determined by the number and the type of muscle fibers affected by the electrical stimulus. As it happened in the Tous-Fajardo et al. (2010) study, in the present study, the time parameters obtained lower statistics than Dm.

In this descriptive study and, as it happened in the Tous-Fajardo et al. (2010) study, the Tr parameter for Gm did not show a significant reliability level, even though the rest of variables of that muscle prove even higher reliability levels over the RF levels. On the contrary, significant differences in other muscles groups could be found in the Križaj et al. (2008) study.

As Rodríguez Matoso et al., (2010) suggest, the Tr could be affected by the intervals between measurements. It is possible that the 3 minutes relaxing interval established in our protocol, which was selected in concordance with Tous-Fajardo et al. (2010) study, had not been enough for recovering the complete muscle relaxation. This would explain the lack of correlation for this parameter. The most difficult factor to control when repeating measurements is the proper position of the sensor over the muscle because the changing position could provoke changes in the muscle response Rodríguez Matoso et al., 2010). In the present study and, also in the Tous-Fajardo et al., (2010) study, the sensor and electrodes were manipulated during the measurements and this could have altered the reliability of some parameters. Herein lays the importance of embracing a measurement protocol that does not affect the muscle response (Rodríguez Matoso et al., 2010).

Besides, following a specific protocol, Tous-Fajardo et al. (2010) points out the importance of taking into account the several individual muscle responses motivated by intrinsic factors such as the skin conductivity, or the thickness of subcutaneous fat. These factors provoked that the individuals needed a higher or lower stimulation in the muscle. This explains why we chose muscles that are easily accessible (RF and GM) for this study.

None of the individuals presented soreness during, or after the intervention, although maximum amperage of the device (110 mA) was used. We do not know certainly if that was the maximum muscle response. This fact happened during Tous-Fajardo et al. (2010) study and it is the greatest limitation of TMG.

In conclusion, TMG is a tool with a high degree of reliability and easy reproducibility for the assessment of muscle function, since the results from the present study have shown high levels of correlation between all the evaluated parameters but for Tr and GM. However, it is strictly necessary to define a measurement protocol to follow in each test and avoid misinterpretations in the results.

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