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Relationships between Countermovement Jump variables and Tensiomyography analysis as an indicator of fatigue in elite soccer players

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Abstract

Purpose: The purpose of the present study was to determine the correlations between the values of Counter Movement Jump (CMJ) and Tensiomyography (TMG) in a match day -1 training session, with 12 elite soccer players from English Premier League (Age: 26.3+- 1.8; Weight: 82.1 +- 3.3; Height: 1.81 cm +- 6.9; BMI: 23,24 +- 1,37)

Methods: Physical tests (CMJ) were carried out at the end of the activation in the gym and before training in the field, in the MD-1 session, while the TMG (Rectus Femoris, Biceps Femoris and adductor longus) was carried out immediately before of activation in GYM. Correlation coefficient between the different variables of CMJ and TMG were established and analyzed.

Results: A high negative correlation (-0.95) was established between the Ts- sustain time (right leg) and the duration of the eccentric phase of the CMJ, as well as a moderate-high negative correlation (-0.73) between the Tr- relaxation time (left leg) and the duration of the eccentric phase in the CMJ in the adductor longus (AL) musculature. A moderate correlation (0.56) was also observed between Td- delay time (left leg) and the duration of the eccentric phase in CMJ in Biceps Femoris (BF) and a moderate-high correlation (0.65) between Td- delay time (right leg) and the duration of the eccentric phase in rectus femoris (RFA).

Conclusions: The main finding of this research is that here is a relationship between TMG (rectus femoris, biceps femoris and adductor longus) in Td, Tr and Ts and values in CMJ (eccentric duration and Flying Time: Contact time)), in order to monitoring fatigue in the last day of microcycle, prior to match day.

Keywords: Fatigue, countermovement jump, tensiomyography

1. INTRODUCTION

In recent years, football has evolved with an increase in both physical and technical requirements.[1] Similarly, the profile of professional soccer players has also been modified. Total distance, distance covered at high intensity, number of high-intensity actions, number of sprints, and number of successful passes are some of the parameters that have evidenced this change over time and this aspect has got a direct relation with acute fatigue in soccer players. [2] In sport, the causes of muscle fatigue are complex and not completely understood. [3] Previous studies have analyzed muscle damage and its relationship with muscle fatigue during similar endurance events, finding a significant performance reduction in functional (jump height, leg power output, maximal handgrip force) and biochemical markers (blood myoglobin and creatine kinase). [4] Recently, tensiomyography (TMG) has received attention as a non-invasive assessment of the contractile properties of isolated superficial muscle. Tensiomyography has gained traction by sport and exercise scientists, health specialists, and coaches as a portable, time-efficient measuring tool of muscle response and mechanical muscle analysis through sub-maximal electrical stimulation and digital displacement assessment [5]. Tensiomyography has been incorporated into athlete testing, monitoring, and rehabilitation programs as it offers additional insight into muscle contractile properties [5].

Tensiomyography (TMG) is a novel non-invasive method that measures radial deformation of skeletal muscle, and in turn its contractile properties, in response to an external electrical stimulus. Some TMG mechanical variables (e.g., radial displacement [Dm], contraction time [Tc], and delay time [Td]) have been shown to be sensitive to detect muscle fatigue and able to discriminate athletes with distinct physical qualities and training backgrounds. [6]

Although decreases in jump performance may be used to detect impairments in physical and physiological qualities, to date, it is not clear why this occurs. A possible explanation for these decrements could be related to changes in some muscle mechanical properties, such as muscle stiffness and time-related parameters (e.g., contraction time). [6]

The purpose of the present study was to determine the correlations between the values of Counter Movement Jump (CMJ) and Tensiomyography (TMG) in a match day -1 training session, with 12 elite soccer players from English Premier League, with the aim of evaluating the state of fatigue of the players prior to the match.

2. Method

2.1. Study Participants

Participation was proposed to a total of 26 subjects, of whom 12 professional elite male soccer players were recruited, from the one English Premier League team (season 2021-22), of the first Elite division of England. Both the club managers and the soccer players were informed of the research project orally and in writing, including material and methods, objectives, and purposes of the study. An oral translation, in real-time, from Spanish to English was carried out by the project director, for those subjects who required it in any of the documents. In those subjects who agreed to take part in the study, compliance with the selection criteria was assessed. Before starting the research project, the subjects filled out and signed the informed consent document, as well as a clinical record sheet. Subjects with the following characteristics were included in the present study: soccer players; male sex; more than 8 years of sports practice in soccer; over 18 years; and that at the time of the study they participated in professional soccer competitions. Similarly, those subjects who: had some type of musculoskeletal injury at the time of the study, or in the 2 months prior to the start of the study, and who had not signed the informed consent document, were excluded

FIGURE1

Figure 1. Descriptive Statistics

Anthropometric variables	M ± SD (range)
Age (Years)	26.3 ± 1.8 (14)
Height (cm)	181.53 ± 6.90 (20)
Weight (kg)	82.10 ± 33 (21)
BMI (kg/m^2)	23.24 ± 1.37 (4.43)

M: Averague, SD: Standard Desviation, BMI: Body Mass Index.

2.2. Process and measurements protocols

Initially, an informative document was provided to all subjects, making an oral translation into English if necessary. After obtaining the informed consent of the subjects, the pre-intervention questionnaires were carried out, consisting of a clinical record sheet providing information on date of birth, height, weight, BMI, and injury in the last 60 days.

The order in which the subjects were subjected to the measurements was random, The results of the measurements were checked at the end of the training.

The only information shared with the subjects was that strictly necessary for the correct execution of the test through verbal communication. No objective feedback or additional information was shared with any subject during or after the testing period. Prior to the execution of the test, standardized warm-up program was carried out for all subjects, serving as a warm-up for the training of the team.

Regarding the measurement protocol, after shaving and cleaning the area, two 5 cm2 adhesive electrodes (TheraTrodeÒ, TheraSigma, Orange, CA, United States) were placed on the respective muscles at a 5cm distance from each other, avoiding the tendon insertions. The negative electrode was placed distal from the measurement point. The measurement point was set at the maximal radial circumference of each muscle, at the thickest part of muscle belly; it was established visually and by palpation of the muscle during a voluntary contraction using an equidistant point from muscle origin and insertion. The electrodes were connected to an electrical stimulator (TMG-S2 doo, Ljubljana, Slovenia) that triggers a quadrangular, monophasic, and 1ms pulse duration wave between 0.1 and 110mA. An accurate digital displacement transducer (GK 40, Panoptik doo, Ljubljana, Slovenia) was positioned perpendicular to the previously established measurement point of the muscle belly. The displacement transducer had a spring constant of 0.17Nmm. The same experienced researcher performed all measures and marks were made in the participant's skin to place the electrodes and displacement transducer at the same place during each assessment. The measurement protocol started triggering electrical stimulus to induce a muscle contraction, whereby the electrical stimulus was started at 40 mA and increased by 20 mA until the maximal radial displacement was obtained. The electrical stimuli were separated from each other by 10 s rest to avoid fatigue or post-tetanic activation. [4] (Figure 1)

From each maximal twitch response, five output parameters were extracted and analysed: Displacement (Dm), the extent of maximal radial deformation (millimeter) of the muscle belly during contraction; Delay time (Td), the time taken from onset of the electrical stimulus to 10% of maximal radial displacement (millisecond); Contraction time (Tc), the time (millisecond) between 10% and 90% of maximal displacement;

Sustain time (Ts), the time (millisecond) between 50% of maximal dis- placement during the contraction phase and 50% of maximal displacement during the relaxation phase, half relaxation time (Tr), the time (millisecond) taken to fall from 90% to 50% of maximal displacement during the relaxation phase. [7]

Lower-body muscular force production measures were obtained through a CMJ conducted on a bilateral force plate with a sampling frequency of 1000Hz (ForceDecks, Vald Performance, Queensland Australia). The CMJ assessment started with the athlete standing on the force plate to calculate body mass. [5]

FIGURE 2

In the CMJ, athletes were instructed to execute a downward movement followed by complete extension of the legs [6]. (Figure 2)

Pearson correlations were conducted between all CMJ and the TMG variables that were identified as being reliable. Correlation coefficients were classified as 0–0.09 = Trivial; 0.1–0.29 = Small; 0.3–0.49 = Moderate; 0.5–0.69 = Large and 0.7–0.89 = Very large .

[5]

3. Results

For statistical analysis, the R- Stats and Jamovi Stats Version 2.2.5.0 version programs were used. For the analysis of normality of the sample, the Shapiro-Wilk test (n <30) was used. Before the beginning of the study, there were no significant differences in any of the variables. Therefore, since p> 0.05 in most of the study variables, we accept the null hypothesis: most of the study variables have a normal distribution.

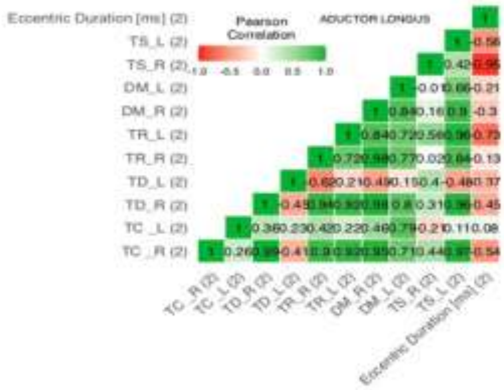


FIGURE 3

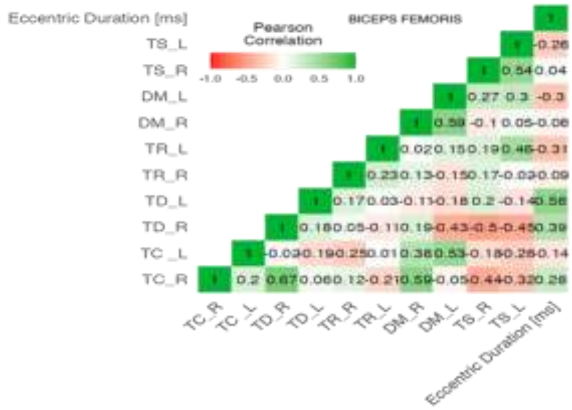


FIGURE 4

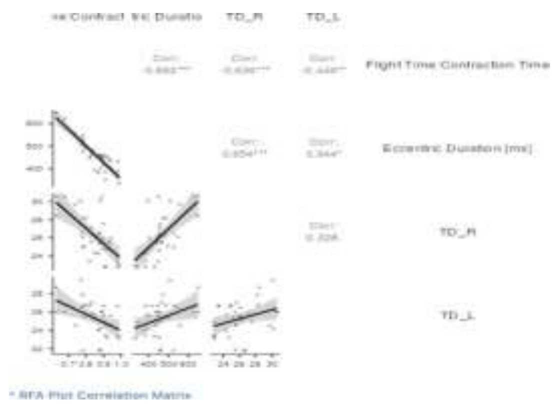
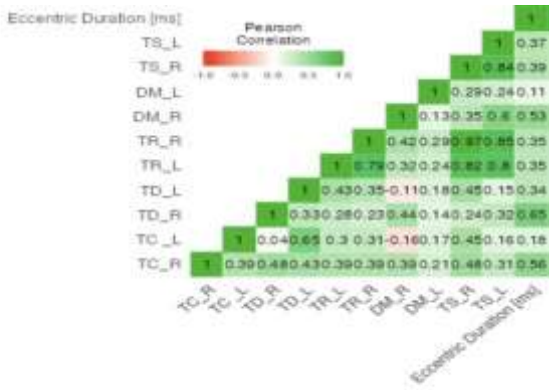
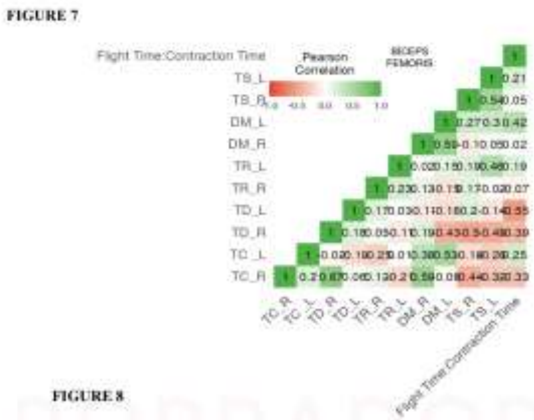


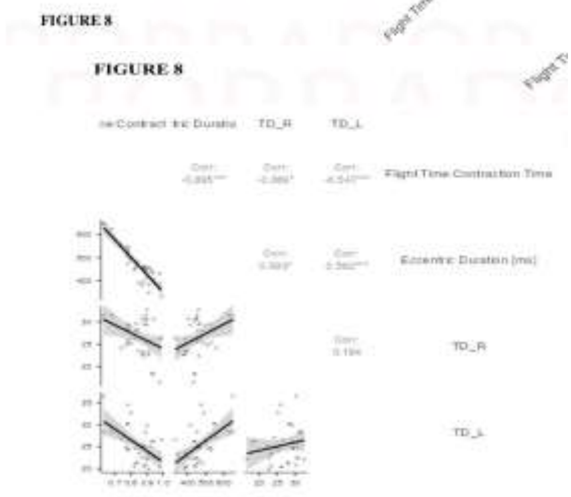
FIGURE 5



* Matrix Correlation Heat Map RFA

FIGURE 6





*BF Plot Correlation Matrix

A correlation matrix was established between the different variables of the TMG and the CMJ. A high negative correlation (-0.95) was established between the Ts-Sustain time (right leg) and the duration of the eccentric phase of the CMJ, as well as a moderate-high negative correlation (-0.73) between the Tr-relaxation time (left leg) and the duration of the eccentric phase in the CMJ in the adductor longus (AL) musculature. (Figure 3) A moderate correlation (0.56) was also observed between Td- Delay time (left leg) and the duration of the eccentric phase in CMJ in Biceps Femoris (BF) (Figure 4) and a moderate- high correlation (0.65) between Td- Delay time (right leg) and the duration of the eccentric phase in rectus femoris (RFA) (Figure 5, 6). There was, as well, a negative moderate correlation (-0,55) between Flying Time- Contact Time (FT: CT) and Td- Delay time (left side) (Figure 7,

4. Discussion

Since impairments in neuromuscular ability were observed in both voluntary (e.g., sprints and jumps) and involuntary actions (e.g., TMG), it is plausible to speculate that these fatigue-related changes are more associated with peripheral. Although it is not possible to determine the actual causes of these acute responses, they might be triggered by a sequence of neuromechanical events, such as reductions in motoneuron excitability, impaired excitatory drive to α-motoneurons, reduced sarcoplasmic reticulum Ca2+ release rate, and excitation-contraction coupling impairment [6]

Previously, tensiomyography has been proposed as a new method to detect fatigue and muscle damage, but there is no consensus about its sensitivity, considering evidence that supports this idea and other evidence that does not. [4]. However, reliability of TMG parameters has been reported widely, and they have been shown to be useful in estimating muscle fiber type, assessing the efficiency of different training programs, and identifying muscle injury [4].

In other researches, shows radial muscle displacement, as well as the time values provided by tensiomyography, is very sensitive to muscle fatigue and to a certain extent also to the initial pressure of the sensor tip on the muscle. [3]. When discussing the correlation between TMG results and CMJ performance, there were no significant relationship. Other previous research in a study of Brazilian elite soccer players did identified no correlations between TMG parameters and power-related motor tasks [5].

Another important factor within TMG measurement is the capability to reliably measure mechanical and contractile properties of muscles across a number of muscle conditions, e.g., at rest, after warm-up, after a maximal voluntary contraction (MVC), and in fatigued conditions. [7]. Although in our study, the TMG parameters that had the most correlation were Tr, Ts, and Td, Tc, and Dm are the most commonly reported parameters when TMG is performed. [7]. Even so, a number of studies have been able to demonstrate fatigue-related changes in TMG measures in adults in cases in which exercise-induced muscle damage and/or muscle soreness as well as a decline in performance, peak force, and/or rate of force development was observed [8, 9, 10, 11].

Taking into account the results of our study, and the correlations established between different parameters of TMG in BF, RFA and AL, and CMJ (especially duration of the eccentric phase as an indicator of fatigue) a potentially effective tool for detecting post-exercise muscle fatigue is tensiomyography (TMG), which was introduced as a non-invasive, motivation-independent, and involuntary measure of muscle contractile characteristics (i.e., peripheral fatigue) designed to work without producing additional fatigue [8].

In addition, the justification of measuring the 3 muscle groups (BF, RFA and AL) is because easiness of using this tool compared to others like electromyography or biomarkers combined with high levels of reproducibility and reliability for measuring vastus medialis, vastus lateralis, rectus femoris (RF), and biceps femoris (BF) and makes it a reliable method for comparing muscle response in different players [12].

Although one of the objectives of our study was not to analyze the differences between TMG values in both limbs, we have differentiated the results of this according to the 2 limbs. Curiously, whereas TMG parameters have been extensively assessed in soccer players, in general, it is performed solely in the dominant limb or considering the mean values for the two legs.

However, differences between limbs are expected in this population as soccer athletes generally favor the use of one specific leg for ball kicking and forceful maneuvers such as cutting [13].

We must be cautious since other studies with elite soccer players showed that, for this specific group of athletes, there were no correlations between tensiomyography parameters and power-related motor tasks [14]. In conclusion, our research suggests that the use of TMG in combination with CMJ as an indicator of fatigue in an MD-1 session could be useful, with emphasis in musculature of lower limbs responsible of power tasks as jump (Biceps Femoris, Rectus Femoris, and Adductor Longus), in order to monitoring fatigue in the last day of microcycle, prior to match day, taking into account that the variables most related to the CMJ were those related to fatigue parameters such as FT: CT, and eccentric duration

Limitations of the study and future lines of research

The sample size of this study was only 12 players, although taking into account that these are premier league players, the scarcity of the sample is compensated by the type of sample, making it difficult to find studies with a representative sample of soccer. Another limitation is that the study was reduced to the evaluation of the parameters in the MD-1 session, future lines of research could be in carrying out this same performance during different moments of the competitive microcycle.

5. Conclusion

In conclusion, according with our research, there is a relationship between TMG and values in CMJ, with a high negative correlation established between the Ts- sustain time (right leg) and the duration of the eccentric phase of the CMJ, as well as a moderate-high negative correlation between the Tr- relaxation time (left leg) and the duration of the eccentric phase in the CMJ in the adductor longus (AL) musculature. A moderate correlation was also observed between Td- Delay time (left leg) and the duration of the eccentric phase in CMJ in Biceps Femoris (BF) and a moderate-high correlation between Td-Delay time (right leg) and the duration of the eccentric phase in rectus femoris (RFA). There was, as well, a negative moderate correlation between Flying Time- Contact Time (FT: CT) and Td- Delay time (left side). These data allow us monitoring fatigue in the last day of microcycle, prior to match day, taking into account that the variables most related to the CMJ were those related to fatigue parameters such as FT: CT, and eccentric duration.

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