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# **THE IMPORTANCE AND ROLE OF THE ISOMETRIC LEG PRESS TEST IN THE TECHNOLOGICAL PROCESS OF TRAINING PROCESS MANAGING**

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*Original research:*

## **Abstract**

The evaluation of muscle characteristics in an isometric regime of exertion is a widely applicable and highly practical method for testing athletes. In these types of tests the examinees act with muscle force against an immovable support which is connected to a measuring probe (converter), strain gauge, force platform or similar device which measures manifested force. In order to show the importance of measuring the muscular characteristics of leg extensors' under isometric conditions in the sports preparation system, the methods of analysis and synthesis of the results of previous research, primary and secondary sources have been used. Considering the fact that every substance in nature, and therefore in the system of an athlete, is physical and has a certain structure and form, properties, the ability to coordinate with other objects and fields and the ability to change as a result of the aforementioned factors, the results of previous studies cannot be observed separately, but as a whole. On a general level, by measuring, assessing and analyzing muscle characteristics in an isometric regime of exertion, it is possible to establish a system for the purpose of diagnostics, in the function of training recommendations and prognostics.

Keywords: measuring, leg extensors', athletes, training process

## **Introduction**

Athlete selection and training level diagnosis regarding contractile characteristics, which is controlled with regard to the basic parameters, i.e. regarding the development level of maximal force (F<sub>max</sub>) or explosive force (RFD<sub>Fmax</sub>), according to numerous authors (Wilson and Murphy, 1996; Zatsiorsky and Kraemer, 2006; Ivanović, 2014), can't secure adequately valid data concerning the function of training process

control, nor adequately specific data for optimization of the training process.

In a modern technological process for testing athletes, hardware-software systems with tensiometric sensitive probes are used, which enable records on force changes with a frequency above 100 MHz/s ((Dopsaj et al., 2000; Mirkov et al., 2003; Ivanović, 2014). Such speed of data acquisition provides an option for analysis of records on change of force in the unit of time with regard to the structure of the mechanical

manifestation of the observed contraction, with regard to a desired interval, percentage of maximal force, achieved force level, percentage of time in the function of the duration of the contraction, gradient of force produced in the unit of time..., i.e. it is possible to analyse all the mechanical characteristics of the force record (Dopsaj et al., 2010; Andersen et al., 2010; Ivanović, 2014). Data obtained with this type of technological testing procedure, is one of the crucial part in the procedure of

information gathering when it comes to controlling and monitoring the training level of the athletes (Dopsaj et al., 2010; Ivanović et al., 2010; Ivanović, 2014).

**Figure 1** Apparatus for measuring maximal leg extensors' isometric force with hardware-software equipment



## Methods

In order to show the importance of measuring the muscular characteristics of leg extensors' under isometric conditions in the sports preparation system, the methods of analysis and synthesis of the results of previous research, primary and secondary sources have been used.

## Results with Discussion

Contractile muscle characteristics measured in unilateral and bilateral isometric conditions of exertion have been the subject of numerous pieces of research over the years, the field of sports and also in rehabilitation and ergonomics. The measuring

of muscle isometric characteristics in sport is widespread, primarily with the aim of gathering information with regard to certain

choices, with the aim of controlling the training levels of athletes, with the aim of providing standards for individual sports disciplines, to define differences between the performances of athletes at different competitive levels, to define differences between the performances of athletes in the function of gender, or to evaluate the effect of physical exercise or training programmes (Jarić et al., 2002; Ivanović et al., 2009; Ivanović, 2014).

Based on the results obtained from previous studies (Ivanović, 2010; 2013; 2014) new parameters and characteristics of the F-t

curve were defined, regarding the training level of the athlete, monitoring, controlling and optimization of the training process:

Realised force at the level of 100% is the indicator of contractile potential of force development at the level of muscle contraction ( $F_{max}$ ), i.e. in the case of gradient – intensity of the rate of force increase is the level of basic explosiveness ( $RFD_{BASIC}$ ) (Ivanović 2010; Ivanović et al., 2011).

Realised force at the level of 50% ( $F_{50\%}$ ) is the indicator of contractile potential of the force development at the level of 50% of maximal muscle contraction ( $F_{max}$ ), i.e. in the case of gradient – intensity of the rate of force increase is the level of specific explosiveness ( $RFD_{50\%}$ ), defining the contractile potential related to the startup acceleration (*S gradient*) of the movement (Zatsiorsky, 1995; Ivanović, 2010; 2014).

Force realised at 250 ms of maximal force is an indicator of the contractile potential of force development at the level of 250 ms of  $tF_{max}$ , i.e. of the maximal muscle contraction ( $F_{250ms}$ ), i.e. in the case of gradient – intensity of the rate of force the increase is the level of specific explosiveness in a given time interval of 250 ms ( $RFD_{250ms}$ ) (Aagaard et al., 2002; Andersen et al., 2010; Ivanović et al., 2010; Ivanović et al., 2011; Ivanović, 2014).

Realised force at 180 ms of maximal is an indicator of the contractile potential of force development at the level of 180 ms of  $tF_{max}$ , i.e. of maximal muscle contraction ( $F_{180ms}$ ), i.e. in the case of gradient – intensity of the rate of force increase is the level of special explosiveness in the function of time interval of 180 ms ( $RFD_{180ms}$ ) (Aagaard et al., 2002; Andersen and Aagaard, 2006; Ivanović et al., 2010; Ivanović et al., 2011; Ivanović, 2014).

Realised force at 100 ms of maximal is an indicator of contractile potential of force development at the level of 100 ms of  $tF_{max}$ , i.e. of maximal muscle contraction ( $F_{100ms}$ ), i.e. in the case of gradient – intensity of the rate of force increase is the level of special

explosiveness in the function of time interval of 100 ms ( $RFD_{100ms}$ ) (Aagaard et al., 2002; Andersen et al., 2010; Ivanović et al., 2010; Ivanović et al., 2011; Ivanović, 2014).

### **Investigations into the reliability and validity of isometric dynamometry**

Numerous factors can influence the reliability of measurements: fatigue, practice, time between testing trials, circumstances during testing, and certain difficulties that can appear during the measuring, conditions (environment) and so on.

The testing procedure, as a means of measuring, implies the necessity for precise, objective and valid determination, and a numeric expression of the training level, i.e. the development of the given contractile property.

In previous research (Dopsaj and Ivanović, 2011; Ivanović and Dopsaj, 2013) authors have tried to determine the metrological aspect of the specific measuring property, i.e. which test trial could give real information on a certain specific contractile property. While analysing the reliability and validity of contractile characteristics for leg extensors' isometric muscle force for the sample of 99 well trained males and females, in four trials, the results showed that the reliability values were statistically significant at the level  $p < 0.05$  for all the observed characteristics (Dopsaj and Ivanović, 2011). On the general level, analysis has shown that the results of the fourth trial in males and the second trial in females were the most reliable, and that those results can explain 97.81% i.e. 96.41% of valid variance. At the partial level, the communality of the measured characteristics of leg extensors' muscle force in both males and females was highest in the second trial. Based on the results of the study, it was concluded that the measuring standardization of leg extensors' muscle force in the seating position in isometric conditions demands 3 trials, with

the better value from the last two trials chosen. Besides, for the purpose of establishing test reliability and defining the methodical procedure of the test for evaluating maximal leg extensors' isometric force and explosiveness, the research was conducted (Ivanović and Dopsaj, 2013) among differently trained athletes from the sports with different conditions for training activity – water, grass, floor, i.e. water polo as a water sport, basketball as an indoor sport on the floor, football as a grass sport and a control group of untrained adults with no previous physical training experience. Based on the obtained results, from the aspect of a methodology of testing different characteristics of isometric force in differently trained athletes, it can be concluded that test standardisation demands two trials in football, three trials in water polo and basketball, and four trials in the control group. From the aspect of research methodology, the results showed the necessity for different methodology approaches for testing leg extensor muscle force in differently trained sections of the population, and with different training histories (Ivanović and Dopsaj, 2013).

### **Investigations into functional and gender dimorphism**

It is a well-known fact that the human body and the skeletal muscle system have a certain balance from the aspect of the anatomic or functional development of the extremities. The biomechanical cross section of the axes in body depend on normal proportions between upper and lower, frontal and back, left and right parts of the body. They can be transformed into smaller systems, such as joint system (the knee for example). As the functional disproportion is greater, the possibility to damage muscle/or bone-joint system is higher (Schiltz et al., 2009).

In the paper from Ivanović et al. (Ivanović et al., 2010) the differences between the

indicator for estimating explosive leg extensor muscle force regarding genders were defined. Higher average values for the examined basic, specific and special characteristics of leg extensors' explosive force were measured among male examinees. Different factors, and most presumably the area of cross-section muscles, the composition of muscles fibers, and muscle mass, as direct factors that affect muscle force manifestation, are some of the basic reasons for the obtained differences between measured examinees of both genders. Under the presumption that individual sports branches can influence the contractile characteristics of leg extensor characteristics, and the level of specific adaptation in different sports disciplines with regard to the natural level of functional and sexual dimorphism in the previous research (Ivanović, 2013; 2014), the aim is to examine the influence of long-term training efforts in the observed sports groups where one leg is used dominantly. At the level of functional dimorphism with regard to different sports groups of both genders at the general level, no statistically significant difference for the examined explosiveness indicators was discovered. Statistically significant differences were established in almost all observed explosiveness indicators for the leg extensors in top level athletes from the speed-strength group in both male and female examinees. This wasn't the case for other groups of examinees.

### **Investigations of the structure of different indicators for the evaluation of isometric contractile muscle characteristics**

In previous research (Ivanović and Dopsaj, 2010; Ivanović et al., 2011) aimed at finding the structure of different indicators of explosiveness in the population of female athletes, but also differences in the structure of explosiveness indicators with regard to differently trained female athletes. The results

showed that, especially in relative indicators of leg extensors' explosiveness, the abstracted variable in the first factor belongs to a space which is, from the motoric aspect, responsible for the realization of specific technical-tactical demands, frequent changes of direction, jumps, different accelerations and so on in a large number of sports disciplines (Ivanović and Dopsaj, 2010).

Hence, the fact that the record of force-time dependency was not just described using maximal force values ( $F_{max}$ ) indicates the necessity to determine the structure of the space from the aspect of the force manifested during isometric contraction, in order to modernise and redesign the testing method with regard to athletes with different training levels, competitive tendencies, gender and so on. In paper from Ivanović (2013) was an attempt to expand research dealing with the characteristics of isometric muscle force and explosiveness. Based on the results of this research, it seems that the significance of the dominant leg had an influence on defining the structure of explosive force characteristics with regard to different sports groups (Ivanović, 2013). The results obtained in this research show that measured characteristics of leg extensors' explosive force obtained in unilateral and bilateral regimes of exertion with regard to different sports groups have different structures in the function of isolated factors under the influence of different mechanisms with regard to the training process.

### **Investigations of correlations of different indicators for the evaluation of isometric contractile muscle characteristics**

Explosiveness and the strength of lower extremities have a high degree of influence on the level of performance for different technical-tactical demands in numerous sports therefore, there are numerous papers in literature that have the aim of examining the correlation between demonstrated force

obtained by applying a certain maximal isometric force measuring method, and tests for the estimation of performance. The correlation between muscle force characteristics and functional properties of motion is usually called the "external" validation of tests for the estimation of muscle force. This type of research is eligible and significant because, based on its results, conclusions which can show the role of force and explosiveness in certain sports can be drawn.

However, the fact that besides the significant role of force and leg extensor muscle force explosiveness, just a few authors have dealt with the relation between the space of contractile characteristics of the leg muscles, especially from the aspect of specific and special force parameters and explosiveness, is surprising. Besides the evident influence of certain sports branches on the production of explosive force with regard to differently trained athletes, and consequently differences in all levels of explosiveness, from the aspect of theory and technology of training, it is highly significant to establish all the characteristics of any relation between different physical properties, in controls, the untrained population, and in the differently trained population as well, from the aspect of different criteria such as gender, age, competitive level and different periods of training. But it is more important to establish all the characteristics (direction and intensity of relations) within the same physical property, because this is the only way to improve basic and specific knowledge in sports science while using the method of confirmation theory. In previous research contrary results have been obtained with regard to relations between explosiveness and the different physiological parameters. One of the reasons for this is in the fact that RFD in different time intervals from the beginning of muscle contraction occurs under the influence of control of different

organs, and is adjusted with the needs of motoric tasks, i.e. motoric exertion. Besides this, different training processes have their own influence on selective adaptation and maximal force.

Besides, taking into consideration that only a few items of research dealt with the relation between maximal force and specific explosiveness characteristics (Andersen and Aagaard, 2002; Andersen et al., 2010; Ivanović et al., 2011), a paper from Ivanović (2013) tried to expand studies on this topic and to question relations within different levels of explosiveness with regard to different groups of sports.

Based on the results obtained from this study (Ivanović, 2013) regarding the observed different sports groups, there are differences among groups at the level of the number of indicators that are mutually correlated, and at the level of connection between explosiveness indicators. In examinees, controls of both gender, consisting of untrained young healthy people, a significantly lower number of correlations between observed indicators was established. Based on this data we can conclude that the space of relation for characteristics within the same physical property is influenced by a regular training process and adaptation to specific training methods. Based on the results obtained on the tested sample of males in all observed groups, it can be concluded that both a specific and special level of explosive force development in unilateral and bilateral exertion regime are mutually significant and connected to a high coefficient of correlation. Similar results were also obtained for female examinees.

### **Model characteristics research**

In research of Ivanović (2014) of the sample of 378 examinees, different explosiveness indicators for leg extensors in both males and females were defined by using isometric leg press test. Data on model characteristics for

different indicators of leg extensor explosiveness was absent from the available literature, and so the results of this study should provide the most informative indicators. These have the potential to enrich the technological process of managing and monitoring the training level of athletes, so improving control and optimisation of the training process. Based on the obtained mathematical methods with a described dependency of percentile distribution and descriptive values for thirty different indicators of explosiveness, basic, specific and special levels of certain ability regarding the absolute and relative values for top-level athletes, both females and males, from different sports groups in the Republic of Serbia were defined. All measured models have a high predictive level of over 97.0% and have described measured variables that are highly statistically significant. In this way, diagnosis and standardisation of the actual state of the certain measuring space was conducted. Results of this research regarding defined model characteristics, the level of development of indicators for evaluating leg extensors' explosiveness with regard to different sports groups among individuals of both genders, emphasise the influence of adaptation on the different manifestation of muscle force characteristics, but also emphasises a correlation between sports branch and muscle force production.

## **Conclusion**

On a general level, by measuring, assessing and analyzing muscle characteristics in an isometric regime of exertion, it is possible to establish a system:

- ⇒ with the object of **diagnostics**
- evaluation of the actual state of an athlete's preparation level,
- the position of athlete with regard to model criteria,

- the characteristics of defined changes in the athlete with regard to previous laboratory testing and
- defining the general improvement tendency with potential prediction;
  - ⇒ with the **training process** as the object
- suggesting the following stages of training and
- prediction of the projects state;
  - ⇒ with the objective of **prognostics**
- anticipation of competitive results, i.e. athlete's preparation level.

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