

**ISOMETRIC MUSCLE FORCE
AS A PREDICTOR OF A
MAXIMAL MUSCLE EFFORT
IN THE LEG PRESS TEST**

**IZOMETRIJSKA MIŠIĆNA SILA
KAO PREDIKTOR JEDNOG
MAKSIMALNOG
NAPREZANJA U TESTU NOŽNI
POTISAK**

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ABSTRACT

This research aimed to determine whether the manifestation of maximum isometric muscle force at a certain joint angle (80°, 110°, and 140°) can act as a predictor of 1-RM in a leg press movement task. The research was carried out in a group of twenty-four (N=24) male students, within two separated sessions, with seven days of rest between each. The anthropometric measurements and muscle force assessment that is 1-RM, was executed through the training-to-failure method on a leg press machine (leg press, V-Gym Croatia) in the first session. Maximum isometric force (Fmax) of leg muscles was measured using maximum consecutive contractions test, in the laboratory conditions, on leg press machine with the help of dynamometer probe and Globus Ergo Tesys System 1000 software. Having analyzed the results obtained on the linear regression basis, the authors have, with 84,5% precision, inferred that it is possible to assess 1-RM in leg press exercise based on maximum isometric force exerted at the angle of the knee joint of 140°. The results attained may be applied in practice when assessing 1-RM, based on maximum isometric force measurement for a given movement task.

Keywords: muscle force, prediction, 1RM, leg press

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INTRODUCTION

Muscle force is defined as the ability of a muscle to act with a certain force, at any speed of muscular contraction due to the voluntary muscular effort, and thus describes the mechanical characteristics of the movement.

Striving to obtain efficient assessment and prediction of the current level of certain mechanical characteristics of muscles, the muscle force testing has found a wide application, primarily in sports practice. One of the fundamental aims of muscle force testing in sport is to evaluate the maximum voluntary muscle force.

Maximum voluntary muscle force, that is muscle strength, represents the maximum force that a muscle or group of muscles can generate when overpowering large external loads at low rates of muscular contraction or in isometric conditions (Zaciorskyi & Kreamer, 2009).

Isometric conditions represent a manifestation of voluntary muscle (isometric) force, with a constant angle in the joint of the corresponding extremity. It is known that maximum muscle force performed in isometric conditions does not significantly differ from maximum muscle force in slow movements (Smidtbleicher 1992, Zaciorsky i Kreamer, 2009).

The results of the research (Parai et al. 2016) show that there are no vital differences between the equation for the assessment of maximum muscle force in isometric conditions and 1-RM. Furthermore, (Juneja et al. 2010, Bazyler et al. 2015,) claim that the use of the maximum muscle force measurement tests is justified and that it can play an important role in assessing dynamic performance predictions.

However, it is not quite known whether the exertion of maximum isometric force at a corresponding extremity joint can act as a predictor for the manifestation of maximum muscle force in slow movements, that is (1RM) in certain moving tasks.

1-RM is a gold standard for the assessment of muscle force in slow movements, and it represents one maximum muscular effort.

Therefore, this research aim is to determine whether the maximum isometric force exerted at a certain joint angle (80°, 110°, and 140°) can act as a predictor of 1-RM in leg press. The authors suggest that the maximum isometric force exerted at an angle of 140° in the knee joint, in leg press, will be a solid predictor of 1-RM. The maximum isometric force was assessed using the isometric dynamometry method.

Having measured the maximum muscle force, a number of researchers have obtained reliability coefficients in the range of 0,85 to 0,99 (Wilson i Murphy, (1996), Vilijanen et al. (1991), Agre et al. (1988), Bemben i Murphy, (2001), Papadopulous et. al (2008&2012), Ivanović i Dopsaj, (2013), Drake et al. (2017)). 1-RM in leg press exercise was estimated applying an RM test for which, Sale (1991) claims, the reliability coefficient ranges from 0,92 to 0,98 (ICC=0,92-0,98).

The results obtained from this research can be applied in practice when assessing 1-RM based on maximum isometric force measurement for a given moving task.

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METHODS

Twenty-four male freshman students (N=24), from the Faculty of Physical Education and Sport at the University of Banja Luka, took part in the study. All of the respondents are male, of a regular health condition, physically active, and had no physical activity 72 hours prior to the test. They were, also, technically trained for the usage of the leg press machine, that way avoiding the occurrence of possible mistakes during the process of the examination. All of the tests were taken at the Sports Institute within the Faculty of Physical Education and Sport at the University of Banja Luka.

All measurements were carried out in two separated sessions with 7 days of rest between them. Familiarization with the experimental protocol, anthropometric measurements and the assessment of 1-RM in leg press exercise were done in the first session. The measurement of the maximum isometric force of leg muscles exerted in three different knee joint angles in leg press movement was executed in the second session.

After the familiarization with the experimental protocol, all respondents approached anthropometric measurements for which anthropometer and body analyzer (TANITA BC – 418MA, Tokio, Japan) were used. The measurement of anthropometric variables was accomplished according to the International Biological Program (IBP), and in this paper, these have been used: body height, body mass, muscle tissue percentage, fat tissue percentage, MFR-index (the ratio between muscle and fat tissue in the body).

The assessment of muscle force, that is 1-RM, was carried out using the training-to-failure method on a leg press machine (leg press, V-Gym Croatia). The

respondents were asked to lift a load of a given weight the maximum number of times, with the number of repetitions not exceeding 10. The approximate muscle force value was obtained based on the regression equation $1RM = \text{weight} / (1.0278 - (0.0278 * \text{number of repetitions}))$ according to Brzycki (1993). After a ten-minute warm-up, all the respondents did 2 sets with 5 repetitions of additional warm-up, in the leg press exercise, with 100 and 120 kg. It should be mentioned that the identical warm-ups were performed in each of the sessions. In the third set, the weight was progressively increased by 10% for the measurer to predict the optimal weight for the test. If the respondent, due to poor estimation of the meter, succeeded in lifting the given weight more than 10 times in the fourth series, the task would be interrupted only to be continued after a ten-minute break in the fifth series where additional load would be added.

The maximum isometric force of leg muscles was measured with maximum consecutive contractions test in laboratory surroundings on a leg press machine with the help of dynamometer and Globus Ergo Tesys System 1000 software. The respondents performed two maximally voluntary contractions 3-5 seconds long with a one-minute break between the repetitions. Three angles of the knee joint of 80°, 110°, and 140° were measured using the Leica Vetronix - SG12F goniometer. The respondents were asked to perform every repetition from the same initial position. They were, also, asked to place their feet in the width of the hips and to perform the maximum possible muscular effort. The dynamometer was fixed to the

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ends of the machine used, with the fixers specifically designed for this test. The maximum force value (Fmax) was obtained from the derivation of the signal using the Globus Ergo Tesys System 1000 software, registered by stretching the probe of the dynamometer.

The basic descriptive parameters were measured for all the variables, while stepwise multiple regression was used to obtain the regression model as a predictor of 1-RM, with statistical significance set at $p < 0.05$. The SPSS (*IBM SPSS Statistics 20. Chicago, IL, USA*) application program was used for mathematical processing of the

original data, as well as their graphic illustration.

RESULTS AND DISCUSSION

The basic descriptive indicators of anthropometric and motor variables are presented in Table 1. The highest value of maximum isometric force in the leg press task was achieved at the angle of the knee joint of 140° , and it was 4082 N ($3292 \pm 444,24$), then at the angle of 110° , 3848 N ($2842,58 \pm 451,86$). The lowest values of maximum isometric force were noted at the angle of the knee joint of 80° , and they were 2678 N ($2145,83 \pm 266,82$).

Table 1. *The basic descriptive indicators of anthropometric and motor characteristics*

Variables	N	Min	Max	AM	SD	CV
Body height (cm)	24	168,00	190,30	179,63	5,96	0,03
Body mass (kg)	24	57,10	95,00	73,89	8,85	0,11
Fat tissue (%)	24	5,40	21,40	13,28	3,74	0,28
Muscle tissue (%)	24	45,30	52,40	49,69	1,67	0,03
MFR index (%)	24	2,22	9,25	4,14	1,63	0,39
Leg press 80°	24	1720	2678	2145,83	266,82	0,12
Leg press 110°	24	2089	3848	2842,58	451,86	0,15
Leg press 140°	24	2492	4082	3292	444,24	0,13
Leg press 1RM	24	180	340	240	44,74	0,20

Legend: N-the number of the respondents, **Min**-minimum span, **Max**-maximum span, **AM**-arithmetic mean, **SD**-standard deviation, **CV**-coefficient of variation

The assessed value of 1-RM for the moving pattern – leg press, was from 180 to 340 kg ($240 \pm 44,74$). Based on the result of multiple regression from Table 2 and Image 1, one regression model has been secluded

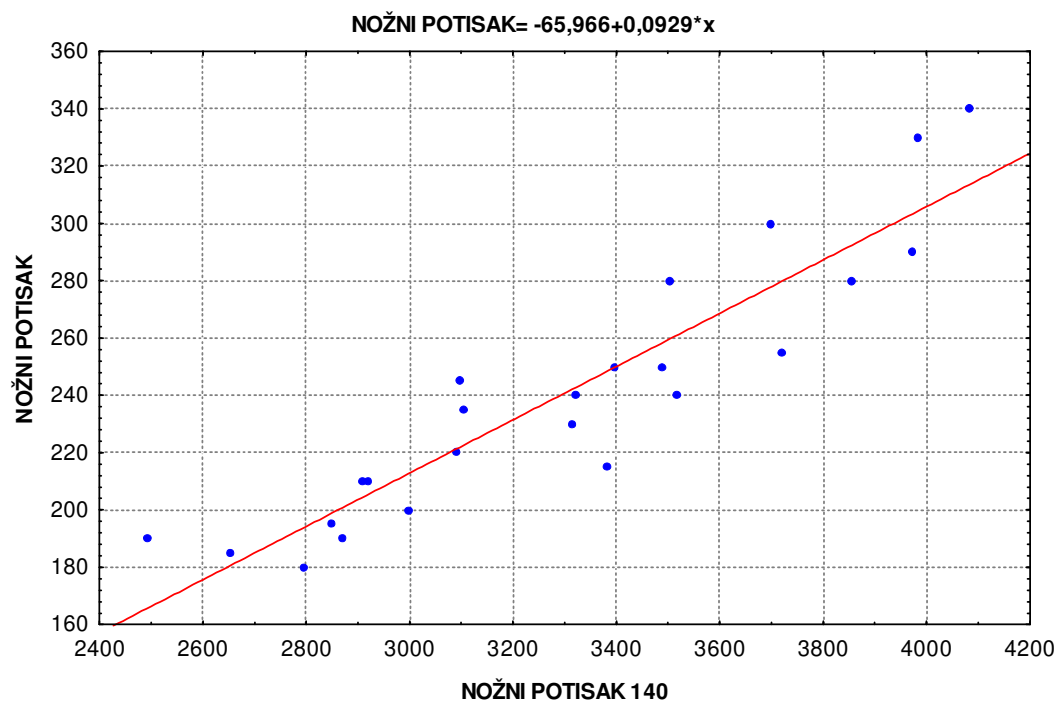
which takes into account only the influence of the subtest "Leg press 140° " and demonstrates that, with the precision of 84,5%, it can predict 1-RM based on the maximum force at a given angle.

Table 2. The regression model for the prediction of 1-RM based on the maximum isometric force applied in the leg press moving task at the angle of the knee joint of 140°

MODEL 1		Leg press=a+b*leg press140°						
Parameters	Parameter values	Standard error	T(20)	P-level	R	R ²	Korig. R ²	st
Equations								
A	-65,966	27,482	-2,400	0,025				
B	0,093	0,008	11,230	0,000	0,923	0,851	0,845	17,6

Legend: MODEL 1 predictor: Leg press 140°, Criterion: Leg press

Image 1. The prediction of 1-RM based on the isometric force exerted in the leg press moving task at the angle of the knee joint of 140°



Twenty-four students voluntarily took part in this study. Based on the average muscle-fat component (MFR) of $4,14 \pm 1,63$ in this group of subjects, it can be concluded that these are the respondents belonging to the muscular-sports morphological type (Ugarković, 1996).

The obtained differences in the exerted muscle force (Table 1), show an increasing

trend in the generation of muscular force, going from smaller joint angles to larger ones. The results show that the highest values of isometric force in the leg press moving task are achieved at the angle of the knee joint of 140°. The results of the "Leg press 140°" variable 4082 N ($3292 \pm 444,24$) are significantly higher than at the angles of 110° and 80°. Such results can be explained

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by the fact that this is an articulated angle at which mechanical preconditions are ideal for exhibiting all parameters related to muscle force. Sale (1991) proposes that isometric measurements be made in the position in which the force range is the greatest for a given range of motion.

What is interesting, and may further justify the generation of greater force at the angle of 140° in the leg press moving task, is the fact that, according to Spairani et al. (2012), the VM (vastus medialis) is more active at larger joint angles, that is, the muscle itself has a grip closer to the knee joint with the fibers in a parallel position to the knee extension. When performing the leg press test, the angle at the hip joint changes with the change at the angle of the knee joint, which additionally results in hamstrings generating muscle force at a higher or lower level.

Analyzing the results, obtained on the basis of linear regression, we can deduce, with 84,5% precision, that we are able to estimate 1-RM in the leg press exercise applying the equation ($Y = -65,966 + 0,0929 * X$), considering that the maximum isometric force is to be measured at the angle of the knee joint of 140°. The standard measurement error was 17,6 kg, or 7,3%, which is acceptable considering that the average result is 1 RM-a $240 \pm 44,74$ kg.

The obtained results analysis has shown that in order for the isometric force variables to be used as predictors for terrain tests it is necessary to perform the tests at an exactly defined body position, keeping in mind the angle at which the test is being

carried out. It seems that the previous researchers' claims, that the muscle force exerted at slow movements don't significantly differ from maximum muscle force exerted in isometric conditions, can be reaffirmed (Smidtbleicher 1992, Zaciorski 2009).

RESULTS

The isometric force value exerted in leg press moving task at the angle of the knee joint of 140° can be considered to be a good predictor of 1-RM, that is one maximum muscular effort in the aforementioned task in dynamic conditions.

The results obtained in this research show that from the methodological aspect this kind of a study approach of the research of myogenic properties is acceptable and that its principles can be used in further research. This type of muscle force measurement can be applied widely, primarily for sports and rehabilitation purposes, in cases where the measurement of muscle force in dynamic conditions is not possible. Further research must be directed to the analysis of the isometric force, as a predictor, obtained at multiple joint angles at a given extremity, which would certainly reduce the standard error of measurement. Furthermore, in addition to Fmax, the force increment (RFD) should be examined for a given task as one of the indicators of the magnitude of myogenic properties. Finally, it should be mentioned that the regularities stemming from this research relate to the sample of the examinees used in it.

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SAŽETAK

Cilj ovog istraživanja je bio da se utvrdi da li ispoljavanje maksimalne izometrijske mišićne sile pri određenom uglu u zglobu (80° , 110° i 140°) može služiti kao prediktor 1 RM-a kod kretnog zadatka nožni potisak (leg press). Istraživanje je sprovedeno na grupi od dvadeset i četiri studenta ($N=24$), muškog pola u okviru 2 odvojene sesije sa po 7 dana odmora između svake. Antropometrijska mjerenja i procjena mišićne sile, odnosno 1 RM-a izvršeno je metodom repetitivnih maksimuma do otkaza na trenažeru za nožni potisak (leg press, V-Gym Hrvatska) u okviru prve sesije. Maksimalna izometrijska sila (F_{max}) muskulature nogu mjerena je testom uzastopnih maksimalnih kontrakcija u laboratorijskim uslovima na trenažeru nožni potisak uz pomoć sonde dinamometra i softverskog sistema Globus Ergo Tesys System 1000. Analizom rezultata dobijenih na osnovu linearne regresije, autori zaključuju da sa preciznošću od 84,5% možemo izvršiti procjenu 1RM-a u vježbi nožni potisak na osnovu maksimalne izometrijske sile ispoljene pri uglu u zglobu koljena od 140° . Rezultati dobijeni ovim istraživanjem mogu poslužiti aplikativno u praksi prilikom procjene 1 RM-a na osnovu mjerenja maksimalne izometrijske sile za dati kretni zadatak.

Ključne riječi: *Mišićna sila, predikcija, 1 RM, nožni potisak*

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