SEXUAL DIMORPHISM IN DIFFERENT INDICATORS FOR EVALUATING ISOMETRIC LEG EXTENSORS EXPLOSIVE FORCE

Abstract

The aim of this paper is to define differences in various indicators for evaluating isometric leg extensors explosive force (RFD\textsubscript{LEGEXTISO}) regarding the gender. 71 examinees divided into 2 groups regarding the gender, male N=39, female N=32, was examined. In order to assess explosive isometric leg extensors force, the standardized equipment was used, tensiometric probe and standardized test in sitting position. Higher values were measured in male examinees in almost all the observed indicators for evaluating isometric leg extensors explosive force at the level of Wilks Lambda 0.475, $F=5.925$, $p=0.000$. Statistically significant differences were established in the following variables: in RFD\textsubscript{BASICLEGEXTISO} $F=29.788$, $p=0.000$; in RFD\textsubscript{50%LEGEXTISO} $F=6.674$, $p=0.012$; in IndexSNG\textsubscript{BASIS} $F=12.731$, $p=0.001$; in RFD\textsubscript{30%LEGEXTISO} $F=7.750$, $p=0.007$; in RFD\textsubscript{50-100%LEGEXTISO} $F=26.558$, $p=0.000$; in RFD\textsubscript{40-100%LEGEXTISO} $F=3.370$, $p=0.000$; in RFD\textsubscript{40-100%LEGEXTISO} $F=4.545$, $p=0.037$; in RFD\textsubscript{40-100%LEGEXTISO} $F=25.421$, $p=0.000$; and in Coeff S/A gradient $F=4.592$, $p=0.036$. The distribution of the results and the values for the coefficient of variation among the observed variables in the male examinees were normal, reliable and homogeneous, in the subsample female results showed declination in distribution, therefore the new indicators can be used in analytics and diagnostic and the obtained results can be used as a criterion for testing, evaluating explosive isometric leg extensors force in different gender population or for evaluating sexual and contractile dimorphism. Apart from variable Coeff S/A gradient, the results of all examined absolute and relative indicators showed higher values in male examinees. The highest differences were measured in RFD\textsubscript{50-100%LEGEXTISO} (170.63%) and the lowest in IndexSNG\textsubscript{SPEC} (11.21%).

Key words: F-t CURVE CHARACTERISTICS / LEG EXTENSORS / STUDENTS/ATHLETES / GENDER DIFFERENCES

INTRODUCTION

Many researchers (Wilson & Murphy, 1996; Milošević, 2002; Zatsiorsky, 2006) claim that diagnostic on physical preparation and athlete selection within the contractile abilities, verified using the basic parameters, that is using the level of maximal force development (F\textsubscript{max}) or explosive force (RFD-F\textsubscript{max}), do not provide valid data which can be used for monitoring of training process. The data on the values of the force development in the function of time generated during the isometric (static) muscle
contraction, with its own characteristics (F-t curve characteristics) are the fundamental data on contractile ability. Therefore, data on F-t curve characteristics of the muscle group are the basic information on athlete’s ability which are gathered with intention to control and monitor athlete physical preparation (Dopsaj, 2005). Technical and tactical requirements in many sports include frequent changes of direction in frontal and lateral plane, numerous high and long jumps, as well as jumps which are characteristic for different sport (Nešić, 2008). Such characteristics require adequate preparation and high performances in terms of sport technique, tactics and both basic and specific physical preparation since there are several jumping techniques in different sports (Zatsiorsky & Kraemer, 2006). No matter what type of jump is being performed during the training or the competition, involvement of leg extensors is 56% (Jarić, 1987). Jarić’s research showed that the highest influence on the height of bounce have maximal isometric force and maximal explosivity parameters in knee joint extensors out of three extensors group in leg joints. The top level athletes need 50 to 250 ms to perform fast moves, while for developing absolute muscle force in most muscle groups they need higher time (300 ms in the elbow flexors and knee extensors) (Andersen & Aagaard, 2006). Therefore, every increase of the RFD in the specific time interval is highly significant because it provides achieving high level intensity of force development in the early phase of muscle contraction (first 100–200 ms), that is consequently efficient and faster motoric, e.g. performance. As the performances increase, the phenomenon of the intensification of the game can be observed, which consequently increase the movement speed, that is decrease time to perform the technique elements, the role of specific characteristics of maximal and explosive force (Zatsiorsky & Kraemer, 2006). Regarding the fact that there were only a few researches on specific parameters of the force, especially in the function of training (Rajić et al., 2004; Rajić et al., 2008; Dopsaj et al., 2009; Ivanović et al., 2009), this research is going to test the new indicators differences for estimating isometric explosive force of the leg extensors in terms of gender. Leg extensors special isometric explosive force differences will be tested, as an indicator of explosive force RFD_{SPLEGEXTISO} level, specific an special Synergy Index (IndexSNG_{SPEC}, IndexSNG_{SPEC}ij), as a criterion for estimating relation of the explosive and maximal force level on the level of 30% and 50% of Fmax, S/A gradient coefficient as a relation of the S gradient and A gradient value, that is the characteristics of developed force in regard to time intervals of 100, 200, 300 ms which are responsible for realisation of specific technical-tactical inquiry, the movements changes, jumps, agility... in large number of sports.

**METHOD**

**Sample**

The subject sample included 71 examinees divided into 2 different groups on the basis of gender: males N=39 and females N=32. The examinees represented physically active population (students of the Faculty for Sport and Physical Education), that is national level athletes (volleyball, handball, athletics, waterpolo and karate) which were tested in the Republic Institute for Sport in Belgrade. The following basic anthropo-morphological characteristics of the tested sample were collected: TV_{FEMALE}=178.02±10.34 cm, TM_{FEMALE}=68.25±7.78 kg, BMI_{FEMALE}=21.59±2.48, Age_{FEMALE}=22.92±2.89 гоpиna; TV_{MALE}=191.99±8.34 cm, TM_{MALE}=87.46±8.62 kg, BMI_{MALE}=23.73±1.92, Age_{MALE}=23.21±2.45 years. All tests were conducted in the Laboratory for assessing the basic motoric status in The Republic Institute for Sport, using the same standardised procedure and equipment. All the examinees – athletes were tested in the similar training period, that is at the beginning of the main pre-competitive cycle. That way we were able to execute unification of the examinees for the purpose of objective results.

**Variables**

The measurement range was defined using 11 variables – 8 absolute and 3 relative defined indicators:

**Absolute values:**

- Basic explosive force of the leg extensors as an indicator of general or basic explosive force level, was done by applying the following procedure
Ivanović J, et al. Sexual Dimorphism in Different Indicators... PHYSICAL CULTURE 2010; 64 (1): 46-61

(Mirkov et al., 2004; Zatsiorsky & Kraemer, 2006):

$$RFD_{BASIC\, LegExtISO} = \left( \frac{F_{max\, LegExtISO}}{tF_{max\, LegExtISO}} \right) \times 1000$$

Where: $F_{max\, LegExtISO}$ represents the maximal value of isometric leg extensors force achieved, and $tF_{max\, LegExtISO}$ represents the time in ms necessary to reach it, expressed in N$\cdot$s.

- The indicator of specific isometric leg extensors explosive force or the S gradient of the leg extensors force, as a rate of force development measured at 50% of $F_{max\, LegExtISO}$ was measured by applying the following procedure:

$$RFD_{S\, LegExtISO} = \left( \frac{F_{50\%\, LegExtISO}}{tF_{50\%\, LegExtISO}} \right) \times 1000$$

Where: $F_{50\%\, LegExtISO}$ represents the value of isometric force achieved at 50% of $F_{max\, LegExtISO}$ and $tF_{50\%\, LegExtISO}$ represents the time in ms necessary to reach it, expressed in N$\cdot$s.

- Acceleration index or the A gradient measured at 50–100% of $F_{max\, LegExtISO}$ was measured by applying the following procedure (Zatsiorsky & Kraemer, 2006):

$$RFD_{A\, 50-100\%\, LegExtISO} = \left( \frac{F_{50-100\%\, LegExtISO}}{tF_{50-100\%\, LegExtISO}} \right) \times 1000$$

Where: $F_{50-100\%\, LegExtISO}$ represents the value of isometric force achieved for 50–100% of $F_{max\, LegExtISO}$ and $tF_{50-100\%\, LegExtISO}$ represents the time in ms necessary to reach it, expressed in N$\cdot$s.

- The indicator of special isometric leg extensors explosive force, as a rate of force development measured at 30% of $F_{max\, LegExtISO}$ was measured by applying the following procedure:

$$RFD_{S\, LegExtISO} = \left( \frac{F_{30\%\, LegExtISO}}{tF_{30\%\, LegExtISO}} \right) \times 1000$$

Where: $F_{30\%\, LegExtISO}$ represents the value of isometric force achieved for 30% of $F_{max\, LegExtISO}$ and $tF_{30\%\, LegExtISO}$ represents the time in ms necessary to reach it, expressed in N$\cdot$s.

- Basic Synergy Index, as a criterion of relation between explosive and maximal force development, expressed in index values (Mirkov et al., 2004; Zatsiorsky & Kraemer, 2006):

$$Index_{SNGBASIC} = \left( \frac{RFD_{BASIC\, LegExtISO}}{F_{max\, LegExtISO}} \right)$$

- Specific Synergy Index, as a criterion of relation between explosive and maximal force development measured at 50% of $F_{max}$, in the range of the S-gradient, expressed in index values (Ivanović et al., 2009):

$$Index_{SNSPEC} = \left( \frac{RFD_{S\, LegExtISO}}{F_{50\%\, LegExtISO}} \right)$$

- Special Synergy Index, as a criterion of relation between explosive and maximal force development measured at 30% of $F_{max}$, expressed in index values (Ivanović et al., 2009):

$$Index_{SNSPEC} = \left( \frac{RFD_{S\, LegExtISO}}{F_{30\%\, LegExtISO}} \right)$$

- Coefficient S/A gradient, as a rate of S gradient and A gradient values was measured by applying the following procedure and was expressed in index values:

$$Coeff\, S/A\, gradient = \frac{RFD_{S\, LegExtISO}}{RFD_{A\, 50-100\%\, LegExtISO}}$$

Relative values:

- Relative values of general leg extensors explosive force measured by allometric method – $RFD_{allom\, LegExtISO}$, $N\cdot$s/$BM^{0.667}$, was done by applying the following procedure (Vanderburgh et al., 1995; Jarić, 2002; Zatsiorsky et al., 2006):

$$RFD_{allom\, LegExtISO} = \frac{RFD_{BASIC\, LegExtISO}}{BM^{0.667}}$$

Where: $RFD_{allom\, LegExtISO}$ represents relative value of general leg extensors explosivity after allometric partialisation, in index number ($N\cdot$s/$BM^{0.667}$); $RFD_{BASIC\, LegExtISO}$ is general leg extensors explosive force in N$\cdot$s; BM is body mass in kg.

- Relative values of the S gradient of the leg extensors force measured at 50% of $F_{max\, LegExtISO}$ by applying the allometric method – $RFD_{allom\, LegExtISO50\%\, S}$, expressed in $N\cdot$s/$BM^{0.667}$, gained by applying the following procedure:
\[ RFD_{\text{allomLegExtISO30\%}} = \frac{RFD_{\text{LegExtISO30\%}}}{BM^{0.667}} \]

- Relative values of the indicator of special isometric leg extensors force gained at 30% of \( F_{\text{maxLegExtISO}} \) measured by applying allometric method – \( RFD_{\text{allomLegExtISO30\%}} \) in N\(^{-}\)s/BM\(^{0.667} \), was done by applying the following procedure:

\[ RFD_{\text{allomLegExtISO30\%}} = \frac{RFD_{\text{30\%LegExtISO}}}{BM^{0.667}} \]

**Measuring procedure**

In order to assess the contractile characteristics of leg extensors isometric muscle force (bilateral), standardized equipment was used, i.e., metal device that measures force in sitting position. Testing was carried out by the hardware-software system M_S_NI CW UI 8.0 (Nikola Tesla Institute, Belgrade) (Figure 1). The tensiometric sounding device was connected to the force reader (force indicator) and to the PC computer (Figure 1).

**Figure 1.** The equipment for assessing maximal leg extensors isometric force with related hardware-software facilities (a) the tensiometric probe within the heels platform (b) force reader with the PC computer (c)

The following procedure was applied: all examinees were tested after five minutes of independent warm-up, with the examinee sitting in order to achieve maximal muscle force in short period of time. The tests were carried out under isometric conditions of exertion with the knee joint at the angle of 110–120°, and with the ankle joint at 90°. The examinees made their attempt after the sound signal. Each examinee had four attempts, with one minute rest between trials. The result was automatic, measured by tensiometric sounding device and hardware-software system, recorded in special database with the possibility of F-t curve inscription control. (Figure 2)

**Statistical procedure**

All the obtained results were statistically evaluated by means of descriptive statistics. Basic measures of central tendency as well as the measures of the dispersion of the results were defined by: arithmetic mean (Mean), standard deviation (SD), coefficient of variation (cV\%), standard error of arithmetic mean (SE\(_{\text{mean}}\)) and 95% interval reliability of average values. Regular distribution of the variables was evaluated by means of index of level of “incline”, skewness and index of level of “curvature” was evaluated by measure of kurtosis. In order to evaluate regular distribution of the data Kolmogor-Smirnov test was used. In order to evaluate general variability differences among the observed groups, MANOVA test was used, while in order to test differences between observed variables multivariate statistical procedure General Linear Model – multivariate procedure (Hair et al., 1998) was used. All statistical operations were carried out by applying: Microsoft Office Excel 2003 and the SPSS for Windows, Release 10.5.0 (Copyright©SPSS Inc., 1989–2002).
RESULTS

Descriptive statistics

The results of the descriptive statistics regarding different gender are shown in Table 1. Distribution of frequency regarding different variables are shown in Figures 1–11.

The results of the Kolmogorov-Smirnov test in male subsample showed that all variables have regular distribution, values of KC are in the range of $p=0.142$ for the variable Coeff S/A gradient to $p=0.822$ for the variable IndexSNGSPEC. In the subsamples female the results of Kolmogorov-Smirnov test have shown irregular distribution in following five variables: Coeff S/A gradient $p=0.013$, RFD $30\%_{\text{LegExt}}$ p=0.023, RFD$_{\text{allomLegExt}}$ $50\%_{\text{ISO}}$ p=0.027, IndexSNG$_{\text{SPEC}}$ p=0.019, IndexSNG$_{\text{SPEC}}$ p=0.013. Asymmetry to the right regarding the normal distribution has been showed in positive presage of coefficient asymmetry in three variables in male subsample: RFD$_{50\%_{\text{LegExt}}}$ (SK=1.404), RFD$_{\text{allomLegExt}}$ $50\%_{\text{ISO}}$ (SK=1.364) and Coeff S/A gradient (SK=1.985). Other positive values of the asymmetry coefficient have shown small and average asymmetry to the right. Evaluating of curvature level of the results in the observed contractile characteristics of the leg extensors values of kurtosis, distribution of the results in the majority of variables didn’t show significant differences in distribution. Three observed variables in male subsample have high values of the level of curvature: RFD$_{50\%_{\text{LegExt}}}$ (Ku=4.916), RFD$_{\text{allomLegExt}}$ $50\%_{\text{ISO}}$ (Ku=4.579) and IndexSNG$_{\text{BASIC}}$ (Ku=2.414) and in female subsample Coeff S/A gradient (Ku=2.671) (Table 1).
Table 1. The descriptive statistic for the total sample

<table>
<thead>
<tr>
<th></th>
<th>Mean±SD</th>
<th>cV%</th>
<th>Sk</th>
<th>Ku</th>
<th>KS (Z/p)</th>
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<tr>
<td><strong>MALE (N=39)</strong></td>
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<tr>
<td>RFD 50%LEGEXTISO</td>
<td>283.270±165.8235</td>
<td>58.54</td>
<td>26.54</td>
<td>229.52-337.01</td>
<td>.784</td>
</tr>
<tr>
<td>RFD 50-100%LEGEXTISO</td>
<td>15812.92±10306.77</td>
<td>65.18</td>
<td>1650.39</td>
<td>12471.85-19153.99</td>
<td>1.404</td>
</tr>
<tr>
<td>RFD 50-100%LEGEXTISO</td>
<td>3656.8±2462.62</td>
<td>67.34</td>
<td>394.32</td>
<td>2858.52-4455.08</td>
<td>1.268</td>
</tr>
<tr>
<td>RFD 30%LEGEXTISO</td>
<td>798.132±516.2806</td>
<td>64.69</td>
<td>82.66</td>
<td>630.76-965.48</td>
<td>1.364</td>
</tr>
<tr>
<td>Coeff S/A gradient</td>
<td>4.875±3.1452</td>
<td>64.51</td>
<td>.49</td>
<td>3.85-5.88</td>
<td>1.332</td>
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<tr>
<td><strong>FEMALE (N=32)</strong></td>
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<tr>
<td>RFD 50%LEGEXTISO</td>
<td>2161.51±1089.12</td>
<td>50.39</td>
<td>192.52</td>
<td>1768.84-2554.16</td>
<td>.870</td>
</tr>
<tr>
<td>RFD 30%LEGEXTISO</td>
<td>808.586±580.2683</td>
<td>71.76</td>
<td>92.92</td>
<td>620.48-996.69</td>
<td>.801</td>
</tr>
<tr>
<td>IndexSNG BASIC</td>
<td>1.5217±0.8005</td>
<td>52.59</td>
<td>.13</td>
<td>1.25-1.77</td>
<td>1.264</td>
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<tr>
<td>IndexSNG SPEC</td>
<td>8.6970±4.7672</td>
<td>54.81</td>
<td>.75</td>
<td>7.14-10.23</td>
<td>.709</td>
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<tr>
<td>IndexSNG SPECIU</td>
<td>14.3972±9.0119</td>
<td>62.58</td>
<td>1.43</td>
<td>11.47-17.32</td>
<td>.368</td>
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<tr>
<td><strong>FEMALE (N=32)</strong></td>
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<tr>
<td>RFD 50%LEGEXTISO</td>
<td>127.8667±58.8416</td>
<td>46.02</td>
<td>10.39</td>
<td>106.64-149.07</td>
<td>.499</td>
</tr>
<tr>
<td>RFD 50-100%LEGEXTISO</td>
<td>9812.61±8991.12</td>
<td>91.63</td>
<td>1589.41</td>
<td>6570.97-13054.25</td>
<td>.993</td>
</tr>
<tr>
<td>RFD 30%LEGEXTISO</td>
<td>1351.17±630.42</td>
<td>46.66</td>
<td>111.43</td>
<td>1123.88-1578.46</td>
<td>.539</td>
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<td>Coeff S/A gradient</td>
<td>8.9384±11.3375</td>
<td>126.84</td>
<td>1.99</td>
<td>4.84-13.03</td>
<td>1.985</td>
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<tr>
<td>RFD 30%LEGEXTISO</td>
<td>573.4462±509.3403</td>
<td>88.82</td>
<td>90.04</td>
<td>389.79-757.07</td>
<td>.985</td>
</tr>
<tr>
<td>RFD 30%LEGEXTISO</td>
<td>9047.69±8990.03</td>
<td>99.36</td>
<td>1589.23</td>
<td>5806.43-12288.94</td>
<td>.861</td>
</tr>
<tr>
<td>RFD 30%LEGEXTISO</td>
<td>528.0834±514.3368</td>
<td>97.40</td>
<td>90.91</td>
<td>342.64-713.51</td>
<td>.868</td>
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<tr>
<td>IndexSNG BASIC</td>
<td>0.9365±0.5166</td>
<td>55.16</td>
<td>.08</td>
<td>.74-1.11</td>
<td>1.042</td>
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<td>IndexSNG SPEC</td>
<td>7.8195±6.2821</td>
<td>80.34</td>
<td>1.10</td>
<td>5.54-10.07</td>
<td>.499</td>
</tr>
</tbody>
</table>
Average value of Basic explosive force of the leg extensors $RFD_{BASIC\text{LEGEXTISO}}$ for the whole sample is $5672.39\pm1089.12$ N·s in male and in female $2161.51\pm1089.12$ N·s. The reliability interval of the average value is at the level of $4538.29–6806.46$ N·s in male and $1768.84–2554.16$ N·s in female (Table 1, Figure 1).

**Figure 1.** Distribution of the frequency $RFD_{BASIC\text{LEGEXTISO}}$ male and female

Average value $RFD_{50\%\text{LEGEXTISO}}$ for the whole sample is $15812.92\pm10306.77$ N·s in male and $9812.61\pm8991.12$ N·s in female. The reliability interval of the average value is at the level of $12471.85–19153.99$ N·s in male and $6570.97–13054.25$ N·s in female (Table 1, Figure 2).

**Figure 2.** Distribution of the frequency of $RFD_{50\%\text{LEGEXTISO}}$ male and female

Average value $RFD_{50-100\%\text{LEGEXTISO}}$ for the sample tested in men is $3656.81\pm2462.62$ N·s and in women $1351.17\pm630.42$ N·s. The reliability interval of the average value is at the level of $2858.52–4455.08$ N·s in men and $1123.88–1578.46$ N·s in women (Table 1, Figure 3).
Figure 3. Distribution of the frequency of RFD\(_{50-100\%\text{LEGEXTISO}}\) male and female

![Graph of RFD\(_{50-100\%\text{LEGEXTISO}}\) distribution for males and females.]

Average value of Indicator of Special isometric leg extensors explosive force RFD\(_{30\%\text{LEGEXTISO}}\) for the sample tested in men is 16070.26±11711.43 N\(\cdot\)s and in women 9047.69±8990.03 N\(\cdot\)s. Reliability interval of the average value is at the level of 12273.84–19866.67 N\(\cdot\)s in men and 5806.43–12288.94 N\(\cdot\)s in women (Table 1, Figure 4).

Figure 4. Distribution of the frequency of RFD\(_{30\%\text{LEGEXTISO}}\) male and female

![Graph of RFD\(_{30\%\text{LEGEXTISO}}\) distribution for males and females.]

Average value of Basic Synergy Index, Index\(_{\text{SNGBASIC}}\) for the sample tested in men is 1.5217±0.8005 and in women 0.9365±0.5166, in index values. Reliability interval of the average value is at the level of 1.25–1.77 in men and 0.74–1.11 in women (Table 1, Figure 5). The average value of Specific Synergy Index, Index\(_{\text{SNG SPEC}}\) for the sample tested in men is 8.6970±4.7672 and in women 7.8195±6.2821, in index values. Reliability interval of the average values is at the level of 7.14–10.23 in men and 5.54–10.07 in women (Table 1, Figure 6).
Average value of Specific Synergy Index, $\text{IndexSNG}_{\text{SPEC}}$ for the sample tested in men is $14.3972\pm9.0119$ and in women $12.1087\pm10.9865$, in index values. Reliability interval of the average values is at the level of $11.47–17.32$ in men and $8.15–16.07$ in women (Table 1, Figure 7). The average value of Coefficient S/A gradient for the sample tested in men is $4.8754\pm3.1452$ and in women $8.9384\pm11.3375$, in index values. Reliability interval of the average values is at the level of $3.85–5.88$ in men and $4.84–13.03$ in women (Table 1, Figure 8).
Average value of $RFD_{allom\,Leg\,Ext\,ISO}$ for the sample tested in men is $283.2708\pm165.8235\, N^{-s}/BM^{0.667}$ and in women $127.8667\pm58.8416\, N^{-s}/BM^{0.667}$. Reliability interval of the average values is at the level of $229.52–337.01\, N^{-s}/BM^{0.667}$ in men and $106.64–149.07$ in women (Table 1, Figure 9). The average value $RFD_{allom\,Leg\,Ext\,ISO50\%}$ for the sample tested in men is $798.1321\pm516.2806\, N^{-s}/BM^{0.667}$ and in women $573.4462\pm509.3430\, N^{-s}/BM^{0.667}$. Reliability interval of the average values is at the level of $630.76–965.48\, N^{-s}/BM^{0.667}$ in men and $389.79–757.07\, N^{-s}/BM^{0.667}$ in women (Table 1, Figure 10).

**Figure 8.** Distribution of the frequency of Coeff S/A gradient male and female

![Figure 8](image1.png)

**Figure 9.** Distribution of the frequency of $RFD_{allom\,Leg\,Ext\,ISO}$ male and female

![Figure 9](image2.png)

Average value of $RFD_{allom\,Leg\,Ext\,ISO30\%}$ in men is $808.5864\pm580.2683\, N^{-s}/BM^{0.667}$ and in women $528.0834\pm514.3368\, N^{-s}/BM^{0.667}$. Reliability interval of the average values is at the level of $620.48–996.69\, N^{-s}/BM^{0.667}$ in men and $342.64–713.51$ in women (Table 1, Figure 11).

**Figure 10.** Distribution of the frequency of $RFD_{allom\,Leg\,Ext\,ISO50\%}$ male and female

![Figure 10](image3.png)
Multivariate analysis

Multivariate statistical analysis established a statistically significant difference at the level of Wilks’ Lambda 0.475, $F=5.925$, $p=0.000$ among the observed subsamples in the function of gender. As for the partial level, the statistically significant differences were established in following variables: in $RFD_{\text{Basic}LegExtISO}$ $F=29.788$, $p=0.000$; in $RFD_{50\%\text{LegExtISO}}$, $F=6.674$, $p=0.012$; in $\text{IndexSNG-Basic}$ $F=12.731$, $p=0.001$; in $RFD_{30\%\text{LegExtISO}}$, $p=0.007$; in $RFD_{50-100\%\text{LegExtISO}}$, $F=26.558$, $p=0.000$; in $RFD_{\text{allomLegExtISO}30\%}$ $F=4.545$, $p=0.037$; in $RFD_{\text{allomLegExtISO}}$, $F=25.421$, $p=0.000$; Coeff S/A gradient $F=4.592$, $p=0.036$.

Table 2. Absolute and relative differences of indicators for evaluating $RFD_{\text{LegExtISO}}$ regarding the gender

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Absolute differences</th>
<th>Relative differences %</th>
<th>Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>$RFD_{\text{Basic}LegExtISO}$</td>
<td>3510.88 N*</td>
<td>162.43</td>
<td>0.000</td>
</tr>
<tr>
<td>$RFD_{\text{allom}LegExtISO}$</td>
<td>155.4041 N*/BM<em>0.667</em></td>
<td>121.54</td>
<td>0.000</td>
</tr>
<tr>
<td>$RFD_{50%\text{LegExtISO}}$</td>
<td>6000.31 N*</td>
<td>61.15</td>
<td>0.012</td>
</tr>
<tr>
<td>$RFD_{50-100%\text{LegExtISO}}$</td>
<td>2305.64 N*</td>
<td>170.63</td>
<td>0.000</td>
</tr>
<tr>
<td>$RFD_{\text{allom}LegExtISO50%}$</td>
<td>224.6859 N*/BM<em>0.667</em></td>
<td>39.17</td>
<td>0.071</td>
</tr>
<tr>
<td>Coeff S/A gradient</td>
<td>-4.063 index *</td>
<td>-45.45</td>
<td>0.036</td>
</tr>
<tr>
<td>$RFD_{30%\text{LegExtISO}}$</td>
<td>7022.57 N*</td>
<td>77.62</td>
<td>0.007</td>
</tr>
<tr>
<td>$RFD_{\text{allom}LegExtISO30%}$</td>
<td>280.503 N*/BM<em>0.667</em></td>
<td>53.12</td>
<td>0.037</td>
</tr>
<tr>
<td>$\text{IndexSNG Basic}$</td>
<td>0.5852 index *</td>
<td>62.49</td>
<td>0.001</td>
</tr>
<tr>
<td>$\text{IndexSNG Spec}$</td>
<td>0.8775 index</td>
<td>11.21</td>
<td>0.506</td>
</tr>
<tr>
<td>$\text{IndexSNG Spec II}$</td>
<td>2.2885 index</td>
<td>18.89</td>
<td>0.338</td>
</tr>
</tbody>
</table>
Table 2 showed absolute and relative differences of the indicator for estimating $RFD_{LEGEXTISO}$ regarding the gender of the examinees. The results have shown that, apart from variable Coeff S/A gradient (index values differences 4.063, 45.45%, $p=0.036$ for the benefit of women), the higher average values of the observed indicators have been measured in men: $RFD_{BASIC\_LEGEXTISO}$ difference 3510.88 N/s, 162.43%; in $RFD_{allop\_LEGEXTISO}$ difference 155.4041 N/s/BM, 121.54%; $RFD_{50\_LEGEXTISO}$ difference 6000.31 N/s, 61.15%; in $RFD_{50-100\_LEGEXTISO}$ difference 2305.64 N/s, 170.63%; in $RFD_{allop\_LEGEXTISO50\_}$$ difference 224.6859 N/s/BM, 39.17%; in $RFD_{50\_allop\_LEGEXTISO}$ difference 7022.57 N/s, 77.62%; in $RFD_{allop\_LEGEXTISO30\_}$ difference 280.503 N/s/BM, 53.12%; in IndexSNG $RFD_{BASIC}$ difference in index values 0.5852, 62.49%; in IndexSNGSPEC $RFD_{BASIC}$ difference in index values 0.8775, 11.21%; in IndexSNGSPEC $RFD_{allop\_LEGEXTISO}50\_$$ difference in index values 2.2885, 18.89%.

Figure 12. Sexual dimorphism in the observed indicators of explosive leg extensors isometric force

Regarding the sexual dimorphism, the coefficient showing the relationship between Female/Male at $RFD_{BASIC\_LEGEXTISO}$ was 0.3865; at $RFD_{50\_LEGEXTISO}$ 0.6160; at $RFD_{50-100\_LEGEXTISO}$ 0.3749; at $RFD_{allop\_LEGEXTISO}$ difference 0.5609; at IndexSNG $RFD_{BASIC}$ 0.6154; at IndexSNGSPEC $RFD_{allop\_LEGEXTISO}$ 0.8991; at IndexSNGSPEC 0.8410; at $RFD_{allop\_LEGEXTISO50\_}$ 0.4578; at $RFD_{allop\_LEGEXTISO30\_}$ 0.7125; at $RFD_{allop\_LEGEXTISO50\_}$ 0.6501; at Coeff S/A gradient 1.7466 (Figure 12).

DISCUSSION

Apart from variable Coeff S/A gradient, the results for all tested absolute and relative indicators for evaluating isometric leg extensors explosive force showed that the male examinees have higher values. Sexual dimorphism in muscle cross section area (leg extensors – 25% less than in women), in muscle structure, muscle architecture, ratio of fibers length and surface of physiological cross section (surface of the fibers type II, 7700 to 4040 $\mu m^2$), the difference in the speed of the nervous activation of the muscle, the difference in skeletal muscle mass (33.0 to 21.0 kg, 38.4 to 30.6%) and statistically significant correlation of the muscle force and cross section muscle area of the leg extensors are the factors that influence on the lower level of muscle force in female subsample in regard to male subsample (Miller et al., 1993; Janssen et al., 2000). The highest differences in the observed indicators of the leg extensors isometric explosive force were measured in acceleration index $RFD_{50-100\_LEGEXTISO}$ and in basic explosive force of the leg extensors $RFD_{BASIC\_LEGEXTISO}$ (170.63% and 162.43%), while the smallest were measured in Specific synergy index (11.21%). In relation to average values of absolute defined indicators $RFD_{LEGEXTISO}$ female examinees have achieved 70.55% smaller values than male. In comparison to average values of the relative defined indicators $RFD_{allop\_LEGEXTISO}$ the value of allometric explosive force in female examinees was at the level of 28.7% in relation to male examinees. Comparing the absolute and relative differences of the indicators at the same level of leg extensors force achieving, the results showed higher differences in absolute values regarding the gender of the examinees, which is sustainable regarding the body mass of the women was smaller (68.25±7.78 kg and 87.46±8.62 kg). higher body mass and higher body mass index in men is the reason for smaller differences between values of relative and absolute indicators not only in achieved explosive and maximal force, but also in strength, durability… Testing the sexual dimorphism of anaerobic capacity in wrestlers applying the Wingate test, Wozniak et al. (2004) established the significant higher level of maximal anaerobic strength, anaerobic strength in kg and FFM in kg are measured in men. The highest differences were measured in maximal anaerobic strength, mea-
The basic leg extension force RFDBASICLEGEXTISO is at the level of 0.6955, and for the maximal absolute trunk extension force is at the level of 0.5240, and for the maximal absolute trunk extension force is at the level of 0.3865), for the maximal absolute trunk flexion force is at the level of 0.5240, and for the maximal absolute trunk flexion force is at the level of 0.5860. In the same research, the time necessary to reach the maximal force is lower in men, especially in higher values of force (in order to achieve the level of force 2000 N men needed 93±24 ms and women 331±191 ms). The coefficient of sexual dimorphism for the basic leg extension force RFDBASICLEGEXTISO is at the level of 0.3865), for the maximal absolute trunk flexion force is at the level of 0.5240, and for the maximal absolute trunk flexion force is at the level of 0.5860. In the same research, the time necessary to reach the certain level of force are perceptible in the function of gender. In the researches mentioned above, differences in time necessary to reach certain level of force were higher than the differences in achieved maximal force regarding the gender. Therefore, it can be concluded that the difference of achieved explosive force in that period of time is higher than the differences in measured values of maximal force regarding the gender. Defining the characteristics of basic and specific parameters leg extensors explosive force in well trained female volleyball players that have competed in Second Division, tested in standing position, Rajič et. al. (2008) obtained the average values of basic leg extensors synergy index, IndexSNGBASIC=0.7598, in index values. Comparing the results of mentioned and our research, the difference is at the level of 18.87% or 0.1767 sufficient for the female subsample and 100.28% or 0.7619 sufficient for the male subsample. Besides, the results of the same research showed that the values of leg extensors explosive force measured in female examinees at the level of 100 ms, 180 ms, 250 ms and at the level of 50% of maximal force surpassed the obtained values of basic explosive force by 4 times. Realization of specific jumping techniques in volleyball yielded higher maximal force, vertical acceleration and storing elastic leg extensors energy during contractile potential of the transitive/intermediate regime of muscle contraction, that is contractile potential of force, that can be established in 250 ms. Under the influence of specific training activity in top level athletes, it is possible to improve speed and initial acceleration, as well as the physical characteristics which are connected to explosive force and reaction of the legs in rebound, sprint, maximal force production, as well as the time necessary to reach maximal force (Rajić et. al., 2004; Zatsiorsky & Kraemer, 2006; Rajič et. al., 2008). That way, with this kind of training activity we were able to higher speed of the explosive-reactive movement, the higher is the muscle force in time intervals 100 ms to 200 ms with the tendency of drifting time-force curve toward the peak of 100 ms, the reduction of time necessary to reach specific level of force and maximal force is significant. This results are confirmed by the results of our research, for the female subsample the indicator of specific leg extensors isometric force surpassed the obtained values of basic explosive force by 4.53 times. In order to define sexual dimorphism of basic
isometric hand grip explosive force, the results have shown that in all observed characteristics, both absolute and relative, statistically significant higher average values were measured in healthy and well trained male students from the Police Academy (Dopsaj et al., 2009b). The coefficient of sexual dimorphism in tested characteristics of basic hand grip explosive force were at the level of 0.5228 for the variable RFD BASIC LHG (left hand grip explosive force) to 0.8474 for the variable RFD Nd/DoHG (functional dimorphism). The results of previous research (Ivanovic et all., 2009) showed that the higher values of the tested leg extensors explosive force characteristics were measured in elite female volleyball players in regard to unspecified and untrained population. The values of standardized differences among the observed variables were in the range from 10731.65 N², that is, 338.32% (unspecified trained female athletes) for the variable RFD 50%LEG EXT ISO to 0.2472 (index value), that is, 31.61% (untrained group) for the variable Index SNG BASIC of deficit in regard to elite female volleyball players. The existence of interaction between sport discipline and leg extensors force production in regard to unspecified trained and untrained population isn’t surprising, especially in athletes, for whom the adaptation is the most intensive at the force level. The participation of leg extensors in sports characterized by great variety of jumps is highly significant. Different training methods and significance of leg extensors in female volleyball players improves explosiveness – relation of RFD and maximal force on the different levels of leg extensors force manifestation in female elite volleyball players in regard to unspecified trained population. Regarding the subsample female examinees, the values of standardized differences were between 0.0927 or 9.27% for variable Index SNG BASIC and 4091.07 N² that is 59.09% for the variable RFD 50%LEG EXT ISO of deficit in regard to female elite volleyball players.

**CONCLUSION**

This paper defined the differences of indicators for evaluating explosive isometric leg extensors force (RFD LEG EXT ISO) regarding the gender. Multivariate statistical analysis determined general statistical significant differences in all contractile characteristics at the level of Wilks Lambda 0.475, F=5.925, p=0.000 among the observed subsamples regarding the gender. Apart from the variable Coeff S/A gradient, the results of all the examined absolute and relative indicators showed higher values in male examinees. The highest difference was measured in variable RFD 50-100%LEG EXT ISO (170.63%), and the lowest in Index SNG SPEC (11.21%).

In regard to the observed contractile characteristics, in the absolute defined indicators for evaluating isometric explosive force, sexual dimorphism was at the level of -0.7466 for the Coeff S/A gradient to 0.6251 for RFD allomLEG EXT ISO30% to 0.5422 for RFD allomLEG EXT ISO. Statistically significant differences were not established in variable RFD allomLEG EXT ISO50% and Index SNG SPEC and Index SNG SPEC/J.

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