

Original research article

## EXPLOSIVE POWER IN GYMNASTS: IS THERE ANY SCIENTIFIC BASIS FOR GENDER DIFFERENCES?

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**Abstract.** *The purpose of this study was to examine potential differences in vertical jump performance between male and female highly trained gymnasts, and to determine the relationship between parameters of the vertical jump performance and skill difficulty on the floor exercise. Forty-six highly trained gymnasts, comprising 15 female (Mean±SD; age: 21.08±1.83 y, height: 159.37±4.87 cm, mass: 50.88±5.41 kg) and 33 male (Mean±SD; age: 21.5±1.79 years, height: 170.67±4.66 cm, mass: 67.08±6.26 kg) consented to participate in study. Results showed statistically significant differences between male and female gymnasts ( $P < 0.001$ ) in jump height and relative and peak power, while no statistically significant differences ( $P > 0.05$ ) were shown between instantaneous powers. Correlation coefficients for CMJ variables were calculated for both groups. Statistically significant positive correlations were found only between D score values and jump height in male gymnasts (0.53) and relative jump power (0.39). Among female gymnasts, statistically significant, but negative correlations between E scores and jump height (-0.64) and with relative power (-0.65), and between F scores and jump height (-0.52) were found.*

**Key words:** artistic gymnastics, vertical jump, floor exercise

### INTRODUCTION

Gymnasts perform different types of jumps during their daily practice, in particular on the balance beam, floor exercise and vault. Bouncing, tumbling and short run-ups followed by dynamic take-offs require the stretch-shortening cycle of muscles (Marina, Jemni, & Rodríguez, 2013). Gymnasts' ability to transmit their impulse from their feet to their upper bodies following rebounds is crucial, allowing acrobatic skills such as somersaulting and

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twisting (Mkaouer, Jemni, Amara, Chaabèn, & Tabka, 2012). Jumping ability of gymnasts is often linked to successful performance and is sometimes considered as an overall indicator of gymnastics proficiency. Success on the floor is largely defined by the ability to jump complex forward and backward rotating skills (Mkaouer et al., 2012). The usual number of jumps with both legs is 1000 to 2000 per week, if all acrobatic elements are considered (Marina et al., 2013).

Previous studies have examined the vertical jump as in gymnasts (Marina et al., 2013); Sands et al., 2008; Swartz, Decoster, Russell, & Croce, 2005). Marina et al. (2013) investigated jumping abilities in seventy-six high trained male and female competitive gymnasts and compared them to a matching control group. They have reported greater differences between the female gymnasts and the female control group than between the male gymnasts and the male control group. The differences between the gymnasts and control groups increased when the countermovement jump (CMJ) and the countermovement jump with arms swing (CMJA) performances were normalized to body mass, especially in men. Mkaouer et al., (2012) compared the take-offs kinetic and kinematic variables underpinning gymnasts' ability to perform the CMJA, the standing back somersault with a landing on a target spot and the standing back somersault with rear displacement in landing. The kinetic analysis showed great similarities between the standing back somersault with landings on the spot and the countermovement jump with arm swing variables of strength, impulse, displacement and peak power on both the vertical and horizontal axis.

Laffaye & Wagner (2013) investigated differences among highly trained athlete's variables from CMJ jumps in different team sports and to explain the link between these variables and demands of different sports. To our knowledge, there are no similar studies involving elite gymnasts. Therefore, the purposes of this investigation were: (1) to determine differences in vertical jumping performance between male and female highly trained gymnasts, and (2) to determine the relationships between parameters of vertical jump performance and success on the floor exercise. We hypothesized that male gymnasts will tend to jump higher than female gymnasts and that because of different composition requirements on the floor; variables of the CMJ will show a stronger relationship with scores on the floor exercise in male than female gymnasts.

## MATERIALS AND METHODS

### Participants

Forty-six high gymnasts, 15 female (Mean±SD; age: 21.1±1.8 years, height: 159.4±4.9 cm, mass: 50.9±5.4 kg) and 33 male (Mean±SD; age: 21.5±1.8 years, height: 170.7±4.7 cm, mass: 67.1±6.3 kg) consented to participate in the study. The procedures involved in the study were in accordance with the Helsinki Declaration and approved by the institutional ethics review board. The data were collected during the Summer Universiade in Belgrade (2009). Written informed consent was given by all gymnasts according to the Institutional Review Board approved protocol. The gymnasts were some of the worlds' best gymnasts; some of these athletes were medalists in the biggest competitions in recent years.

### Procedures

Basic anthropometric parameters (stature and body mass) were measured in the study protocol. The testing took place one day before the beginning of a qualification competition. Immediately prior to testing the participants performed a standard individual, gymnastics warm-up. During testing, the air temperature ranged from 24°C to 27°C. Testing always commenced at 10 a.m. and was completed by 1 p.m.

The vertical jump test required each athlete to perform three CMJ with a 30s passive rest period between each jump performed on a force plate Kistler Quattro Jump (9290AD), according to the protocols described in (Kums, Erelina, Gapeyeva, & Pääsuke, 2005) and criteria for correct trials of jumps according (Acero, Sánchez, & Fernández-del-Olmo, 2012). The jump height, instantaneous power and relative power were calculated directly by the system, determinate from flight time.

The success on the floor exercise event was obtained from the official results book, represented by the difficulty score (Start value of the exercise, given by D panel judges), E score (Execution score by execution commissions' judges) and the F score (Final score on the floor).

### Statistical analysis

SPSS 20.0 was used to calculate group (male and female gymnasts) descriptive statistics (means and standard deviations) and develop correlation matrices for each sex and variables of the CMJ jump. To identify any statistical difference between the grouped sex means for each of the calculated characteristics independent T-tests were conducted and Cohen's effect size (Cohen's d) were calculated to assess the magnitude of any differences observed with the following criteria: >0.70, large; 0.30-0.70, moderate; <0.30, small (Cohen, 1988). Statistical significance was set at  $p < 0.05$ .

## RESULTS

Table 1 shows the descriptive statistics, differences (p value) and effects size (Cohen's d), while Tables 2 displays the correlations between the examined variables.

**Table 1** CMJ male and female mean descriptive statistics, P-value and Effect Size (ES)

	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	p	Cohens' d	ES
Jump Height	39.40	67.60	49.55	5.94	27.00	47.20	37.83	4.71	<b>0.000</b>	1.98	0.70
Instantaneous Power	0.26	1.88	1.17	0.36	0.53	2.22	1.17	0.45	0.988	-0.00	0.00
Relative Power	16.60	37.80	28.74	4.41	19.20	34.90	24.947	4.33	<b>0.008</b>	0.82	0.38
D score	4.00	6.30	5.14	.60	3.10	5.80	4.747	0.73	<b>0.050</b>	0.59	0.28
E score	5.70	9.05	8.19	.63	6.80	8.70	7.977	0.49	0.237	0.35	0.17
F score	10.20	14.70	13.28	.93	10.55	14.45	12.71	1.08	0.066	0.55	0.27

The countermovement jump comparison between female and male gymnasts demonstrated a statistically significant difference in jump height and relative power and peak, while no statistically significant difference ( $P > 0.05$ ) was shown between instantaneous powers. Also, statistically significant differences in scores were observed only in the D score values.

**Table 2** Correlation between the variables of the vertical jump and scores on the floor in male gymnasts

Variable	Jump height	Instantaneous power	Relative power	D score	E score
Instantaneous power	.17				
Relative power	.74**	.77**			
Dscore	.53**	.14	.39*		
Escore	.01	-.16	-.04	.28	
Fscore	.17	.02	.18	.38*	.83**

\* 0.05 level (2-tailed), \*\* 0.01 level (2-tailed)

The correlations for CMJ variables were calculated. Significant positive correlations were found only between the D score and Jump height in male gymnasts (0.53) and relative power of jump (0.39). Female gymnasts showed statistically significant, but negative correlations between the E scores and Jump height (-0.64), and with Relative power (-0.65), and between F scores and Jump height (-0.52).

**Table 3** Correlation between the variables of the vertical jump and scores on the floor in female gymnasts

Variable	Jump height	Instantaneous power	Relative power	D score	E score
Instantaneous power	.59*				
Relative power	.93**	.84**			
Dscore	.05	.48	.25		
Escore	-.64*	-.51	-.65**	.06	
Fscore	-.52*	-.29	-.47	.34	.89**

\* 0.05 level (2-tailed), \*\* 0.01 level (2-tailed)

The present study found relationships between body mass and height and all the variables of the vertical jump ( $r=0.54-0.89$ ), except instantaneous power ( $p>0.005$ ). Correlations between variables of CMJ jump vary from poor to strong ( $r=0.36-0.81$ ), similar to variables that represents success on the floor (D score, E score and Final score).

#### DISCUSSION WITH CONCLUSION

The first aim of the present study was to determine differences in CMJ performance between female and male elite gymnasts. Results showed that there was significant gender difference for the values of jump height, relative and peak powers. Only instantaneous power was not statistically significantly different between males and females. A study by Buško & Gajewski (2011) reported gender differences between genders, but when the results were calculated relative to body mass, the gender differences in some of the values were not statistically significant. In our study, two variables included body mass in the calculation – relative and peak power and both showed statistically significant differences between male and female gymnasts.

Laffaye & Wagner (2013) showed that men tend to jump higher than women (approximately 10 cm) throughout a range of different jump methods. Our results showed slightly higher differences than those found in the literature, because the mean value of the jump height of the male gymnasts was approximately 12 cm (23.06%) higher among males. The authors suggested that differences in jumping performance may have resulted from greater concentrations of androgens, higher relative amount of fast-switch fibers, maturation, greater muscle thickness and cross-sectional areas (Gantriaga, Katartzi, Komsis, & Papadopoulos, 2006; Häkkinen et al., 1996; Quatman, Ford, Myer, & Hewett, 2006).

Marina et al. (2013) on a sample of 76 Spanish gymnasts (45 male and 46 female) and matched control group of untrained participants (41 male and 35 female) reported greater differences between the female gymnasts and the female controls than the male gymnasts and the male control group. Male gymnasts performed the CMJ with an arm swing significantly better than the control group. When the CMJ performance was normalized to body mass, the differences between the gymnasts and the control groups increased statistically ( $P < 0.001$ ), especially in men. The comparison between the best gymnasts and control groups supports the idea of jumping as much as possible, and as lightly as possible. Our results showed a positive correlation between jump height and body mass ( $r = 0.542$ ) in elite gymnast.

Ostojic, Stojanovic, & Ahmetovic (2010) reported that reference values for the CMJ jump should be greater than 56 cm in male and 51 cm in female athletes at the national level of competition. Authors also reported jump height results of elite athletes from different sports, but with different jump protocols. The height of the CMJ in our study is similar to Donti, Tsolakis, & Bogdanis (2014) of male (age  $24 \pm 4$  y, height  $167 \pm 0.03$  cm, mass  $64.3 \pm 4.4$  kg) and female gymnast (age  $18.1 \pm 2.6$  y, height  $160 \pm 0.5$  cm, mass  $49.9 \pm 5.4$  kg) who reported a CMJ jump of  $38.5 \pm 0.9$  and  $29.5 \pm 1.1$  cm, respectively.

The second aim of our study was to determine relationships between CMJ variables and scores achieved on floor exercise. In male gymnasts, jump height and relative power of the jump showed statistically significant correlations with the D score and Final score. Also, many different factors influence performance and success on floor exercise (Hedbávný & Kalichová, 2011), the vertical elevation of a gymnast's center of mass during the aerial phase of a somersault is a crucial parameter for the performance of the acrobatics elements (Mkaouer et al., 2012). This parameter increases the possibility of upgrading the difficulty value of elements with longitudinal and transversal rotations. A greater take-off velocity and height of the COM will result in greater stability of landing, particularly when combined with longitudinal (i.e. twisting) rotations (Mkaouer et al., 2012). Difficulty values of the performed elements have direct influence on the D score, and also final score of the performed gymnastics routine. The same authors concluded that gymnasts who are powerful enough to gain lots of height could perform their somersaults and twists within an ascendant and/or descendant phase of the somersaults and those who cannot jump too high would compensate by a transversal displacement. In contrast, there were negative correlations between variables of the vertical jump and scores on the floor exercise, so the female gymnasts who were explosive probably made more mistakes that affected their score on the floor.

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## EKSPLOZIVNA SNAGA NOGU GIMNASTIČARA: DA LI POSTOJE NAUČNE OSNOVE ZA RAZLIKE IZMEĐU POLOVA?

*Cilj ovog rada je utvrđivanje razlike u izvođenju vertikalnog skoka vrhunskih gimnastičara i gimnastičarki, kao i povezanost između parametara vertikalnog skoka i uspeha na parteru. Uzorak ispitanika činilo je 15 gimnastičarki (uzrast:  $21.08 \pm 1.83$  godina, visina:  $159.37 \pm 4.87$  cm, masa:  $50.88 \pm 5.41$  kg) i 33 gimnastičara (uzrast:  $21.5 \pm 1.79$  godine, visina:  $170.67 \pm 4.66$  cm masa:  $67.08 \pm 6.26$  kg). Rezultati su pokazali statistički značajne razlike između gimnastičara i gimnastičarki ( $p < 0.001$ ) u visini skoka i relativnoj i maksimalnoj snazi, dok nije utvrđena statistički značajna razlika u trenutnoj snazi ( $p > 0.05$ ). Statistički značajne pozitivne korelacije su pronađene između vrednosti polazne ocene na parteru i visine skoka kod gimnastičara (0.53) i relativne snage skoka (0.39), redom. Kod gimnastičarki je utvrđena statistički značajna negativna korelacija između ocene za izvođenje i visine skoka (-0.64), ocene za izvođenje i relativne snage (-0.65), kao i između konačne ocene i visine skoka (-0.52).*

*Ključne reči: sportska gimnastika, vertikalni skok, sastav na parteru*