No. 1, Vol. XIV /2013

G Y M N A S I U M

Scientific Journal of Education, Sports, and Health

ANALYSIS OF EXPLOSIVE AND ELASTIC- EXPLOSIVE STRENGTH OF LOWER LIMBS IN SPANISH YOUNG TOP-LEVEL TABLE TENNIS PLAYERS

Pradas de la Fuente Francisco [1]*,
Castellar Otín Carlos [2],
Ochiana Nicolae [3]

[1,2]*University of Zaragoza, Huesca 22001, Spain*
[3]*"Vasile Alecsandri" University of Bacau, Str. Marasesti, No.157, 600115, Romania*

Keywords: *table tennis, children, explosive strength, lower limbs, vertical jump.*

Abstract

In table tennis a great number of shots are performed at high speed developing high levels of explosive strength of lower extremities. The aim of this study was to determine the explosive and elastic-explosive strength of the lower limbs in Spanish young top-level table tennis players. A total of 165 players (95 boys and 70 girls) aged 7-17 years were randomly selected to participate in the study. Differences in the vertical jumps battery by category, gender and playing styles were observed. The girls obtained best results in the vertical jump in under 13 and cadet category and boys in the under 11 and junior category respectively. This information could have a great useful and interesting as talent detection, training planning method and as physical performance system control in table tennis. The explosive strength is one of very important physical capacities in this sport.

1. Introduction

Table tennis belongs to the racket sports group as badminton, squash or tennis. These sports are characterized by continuous changes of rhythm and intensity, with fast actions of short duration that are repeated during the whole match. During competition, table tennis players need to apply several physical capacities such as speed, strength, cardiovascular endurance, agility, perceptive and taking decision skills, as a consequence of the continuous and changing situations that are typical of this game dynamic (Pradas, Martínez, Castellar, Bataller & Carrasco, 2011).

Lower extremities movements are essentials in table tennis to achieve a right position that allows hitting the ball effectively (Pradas, de Teresa & Vargas, 2005). The player needs to perform short and explosive movements, as a consequence of high-speed frequent changes of direction during the match

* *E-mail*: franprad@unizar.es, 0034 974292562

generating high levels of mechanical power with lower limbs extensor muscles. Moreover, a high and constant state of legs muscle tension is developed, as a consequence of high uncertainty levels that depend on the possible reaction of the opposite player (Pradas et al., 2011). For this reason, muscular power or explosive and elastic-explosive strength are essential variables for assessing performance in table tennis.

Jump test have been frequently used to evaluate peak power output from lower limbs muscles (Lara, Alegre, Abián, Jiménez, Ureña & Aguado, 2006). Indeed, several authors registered data concerning vertical jump parameters in senior table tennis players, establishing differences between offensive and defensive players (Pradas et al., 2005; Pradas, Carrasco y Floría, 2009; Pradas et al., 2011). However, there is a lack of information about mechanical power generated by legs extensor muscles of young table tennis players. These data may serve as criteria for evaluating muscular strength development during training process.

Therefore, the aim of this study was to evaluate the muscle power of lower limbs in young top-level table tennis players considering gender, category and playing styles (offensive and defensive) as a factor.

2. Material and methods

Subjects

A total of one hundred and sixty five Spanish table tennis players (95 boys and 70 girls) aged between 7 and 17 years were included in the study. The subjects were selected between four categories (under 11, under 13, cadet and junior). All players were members of the National Sport Tecnification Program developed by the Spanish Table Tennis Federation at the moment of the study. The general characteristics of subjects are summarized in Table 1. Data are expressed as mean ± standard deviation (SD).

Table 1. *General characteristics of the table tennis players*

	Category	**n**	**Body mass (kg)**	**Height (cm)**	**Body mass index ($Kg \cdot m^{-2}$)**
Boys (n=95)	Under 11	28	36.15±6.1	143±0.06	17.61±2.3
	Under 13	25	43.14±8.5	151±0.07	18.92±2.9
	Cadet	28	53.11±10.3	162±0.07	20.13±3.2
	Junior	14	65.44±8.9	175±0.06	21.38±1.7
Girls (n=70)	Under 11	22	34.91±7.6	140±0.08	17.77±2.8
	Under 13	18	43.07±8.2	151±0.08	18.71±2.8
	Cadet	15	50.69±6.1	159±0.06	20.03±1.6
	Junior	15	59.19±7.2	164±0.04	22.06±2.1

All players passed medical examination within two days before the tests. All the subjects who participated in the study had no injury of their lower limbs. Children that were unable to perform vertical jump tests adequately were

excluded from the study.

Before the study, the coach, the children and their parents and/or tutors had been fully informed about the aim of the research and the procedure before signing a written consent, which was in accordance with the legal requirements and the Declaration of Helsinki and was also approved by the Ethic Committee of the Government of Aragón, Spain.

Test procedure

All subjects performed standardized general warm-up, with five minutes of continuous jogging of low intensity and five minutes of supervised calisthenics exercises. After a brief rest period, they executed three consecutive experimental trials for each jumps, squat jump (SJ) and countermovement jump (CMJ). Five minutes rest period between vertical jump CMJ and SJ was established. In any case, the best attempt (highest jump) was registered. Jumping performance was evaluated with the jumping mat connected to an electronic timer Newtest Powertimer® (Oulu, Finland). The knees flexion angle was controlled in the squat jump using a goniometer. All subjects performed the SJ and CMJ under the supervision of the same operator.

Test was executed following the original protocol for both jumps. Briefly the description of the jumps types:

- Explosive manifestation of strength (SJ). It is a jump without previous countermovement, starting from a 90º knees position. With the hands on the hips, legs must be extended during the jump. The legs contact the floor with front foot and extended knees. This test calculates the value of explosive strength, the capacity of synchronization and the instantaneous recruitment.
- Elastic-explosive manifestation strength (CMJ). Jump in countermovement with a fast legs flexion-extension. The flexion knees must reach 90º. The difference with SJ is the use of elastic energy. It measures the elastic capacity.

The selected motor tests allowed the evaluation of contractile and elastic component of the lower limbs musculature, by means of the height of the vertical jump of the evaluated subjects.

Statistical analyses

Data were analyzed using the statistical software SPSS 19.0. Standard statistical methods were used for calculating mean values and arithmetic means ±SD. The Kolmogorov-Smirnov test was applied to determine the nature of data distribution. Since a normal distribution was confirmed, a t- test was performed to examine statistical differences between gender and category. Statistical significance was set at $p \leq 0.05$.

3. Results and discussions

The SJ and CMJ values of vertical jumping (means, maximum, minimum and standard deviations) and elastic index (EI) recorded in table tennis players according to category and gender are summarized in Table 2.

Table 2. *Descriptive values obtained from the SJ and CMJ tests*

Category	Age (years)	SJ (cm)	Max. (cm)	Min. (cm)	CMJ (cm)	Max. (cm)	Min. (cm)	Elastic Index
Under 11 ♂	9.3±0.7	19.9±3.8	27.7	11.6	22.3±3.4	27.7	14.8	2.4±1.8
Under 11 ♀	9.7±0.5	18.2±3.4	24.7	13	20.4±3.4	29.4	15.5	2.2±1.6
Under 13 ♂	11.4±0.5	21.1±4.5	30,5	13,1	24±4.9	36.3	16.2	2.8±1.7
Under 13 ♀	11.5±0.5	21.3±5.4	37.8	12.8	24.7±5.3	40.4	15	3.4±1.8
Cadet ♂	14±0.8	26.6±5.2	36.2	15.2	28.8±5.3	38.7	17.1	2.1±1.2
Cadet ♀	13.5±0.7	27.2±4.7	35.4	18.7	29.5±4.6	38.7	23.8	2.3±1.7
Junior ♂	16.3±0.4	30.9±4.4	41.7	23.2	34±3.8	42.7	28.5	3±1.7
Junior ♀	16.6±0.4	25.5±5.8	17.3	35.4	27.8±6.4	37.4	18.1	2.3±1.6

♂: boys; ♀: girls

Explosive strength (SJ) and elastic explosive strength (CMJ) changes as age increases in all the tested categories (under 11, under 13, cadet and junior) and in both genders, although differently between boys and girls (Fig. 1).

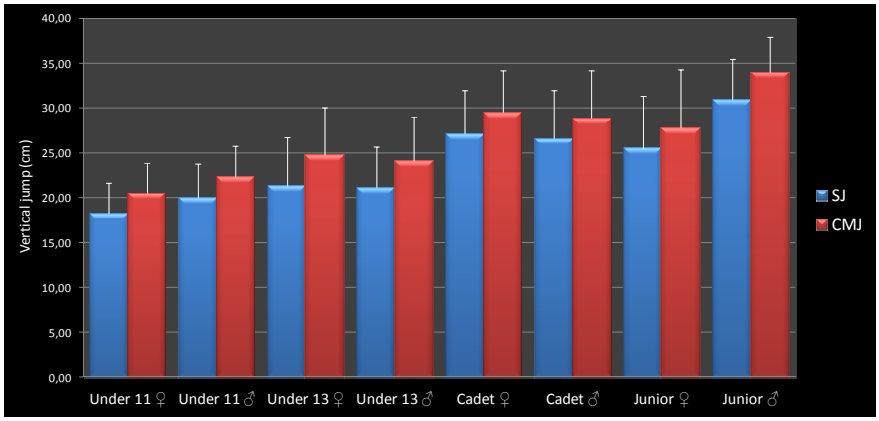

Figure 1. *Distribution of SJ and CMJ values according to category and gender*

Girls tend to achieve higher levels of explosive and elastic-explosive strengths both in under 13 (SJ: 21.3 ± 5.4 and CMJ: 24.7 ± 5.3 vs SJ: 21.1 ± 4.5 and CMJ: 24 ± 4.9) and cadet categories (SJ: 27.2 ± 4.7; CMJ: 29.5 ± 4.6 vs SJ: 23.4 ± 6.4; CMJ: 25.6 ± 7.4). However, in the junior category the results of both tests are reversed. Higher strength values are achieved by male players (SJ: 30.9 ± 4.4, CMJ: 34 ± 3.8) when compared to females (SJ: 25.5 ± 5.8; CMJ: 27.8 ± 6.4) that suffer a decrease statistically significant both for SJ ($p<0.02$) and CMJ ($p<0.01$) (Fig. 2). These results may be related to girls' passive mass growth (Manno, 1999) and higher levels of plasma testosterone in males (Bosco, 2000).

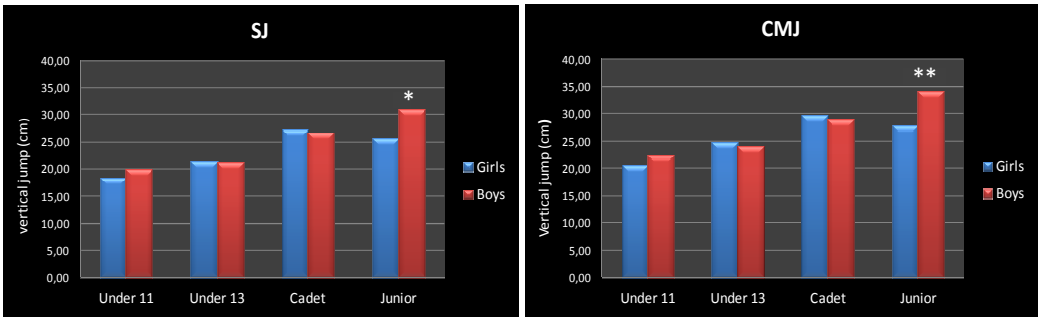

Figure 2. *SJ and CMJ values recorded in all tested categories. * p<0.05; ** p<0.01*

The CMJ and SJ values obtained in the under 11 category are similar to those obtained in a recent study performed in a school population (Gonzalez, Diaz, Garcia Mora, Castro & Facio, 2007). Starting from under 13 category the results obtained in primary school children are lower than those obtained in table tennis players. These differences can be explained as a result of sport specialization developed over the years by training.

Starting from cadet category, values obtained by males are superior in both tests, and in the junior category these differences become significant both for SJ ($p<0.05$) and CMJ ($p<0.01$). These differences may depend on the high serum concentrations of testosterone improved by the nervous system and promoted by the quick fibers fenotype. Boys achieved better results than girls for developing stronger gradients of explosive force (Bosco, 2000).

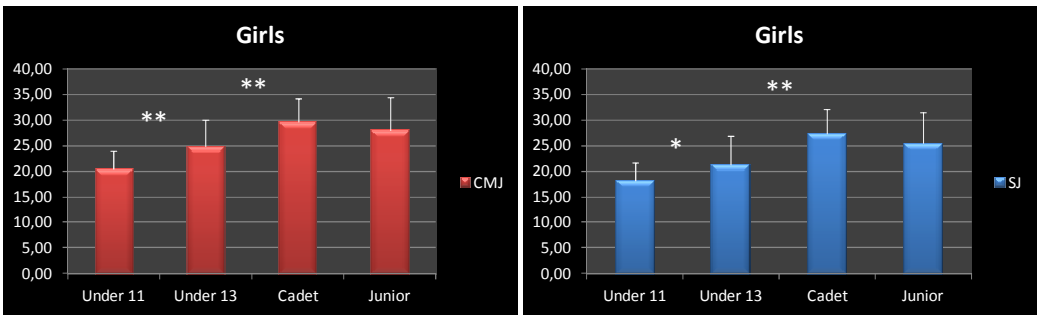

Figure 3. *SJ and CMJ values/category in girls. * p<0.05; ** p<0.01*

In both sexes, from the under 11 to the cadet categories a constant and linear explosive strength improvement has been detected (Fig. 2 and 3), this occurrence is more evident in girls at the onset of pubertal stage, obtaining better values than boys in the SJ and CMJ tests. However, junior female players suffer a drop in performance in both tests. This behavior may be related to biotypological factors since in the junior stage male players develop greater lean mass while women tend acquire up to 10% more fat (Bosco, 2000).

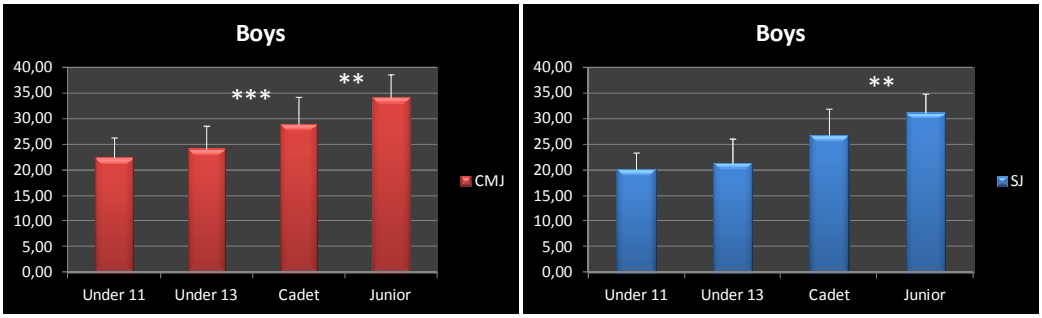

Figure 4. *SJ and CMJ values/category in boys. ** p<0.01*

All tested subjects, independently form the gender, get higher results in the CMJ test rather than in the SJ test. These differences may depend on the previous stretching performed in the push phase using the elastic and neuromuscular characteristics (Bosco, 1994; Bobbert & Richard, 2005) and on the fact that men tend to develop more legs muscular power than women, when the load to displace is minimal (Bosco, 2000).

The difference between SJ and CMJ tests correspond to the elasticity index (EI = [CMJ-SJ)/SJ]*100) (Bosco, 2000). The EI is crucial in sports where jumping ability is important and in those that require fast and explosive movements as table tennis (Fig. 5). No statistically significant differences were found in EI between genders. Higher EI levels are achieved in the under 13 category in females (3.43) and junior category in males (3.06). Similar results were obtained by González et al. (2007) in 10-12 years old school children. The values obtained in the junior category are also similar to those found in high level senior table tennis players (Pradas et al., 2005).

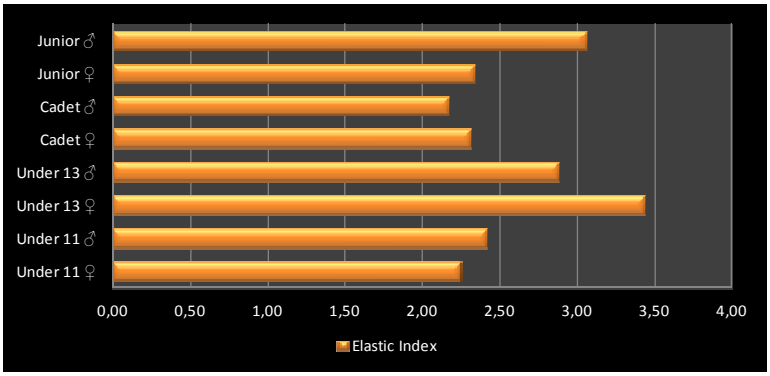

Figure 5. *Elastic index values recorded in the tested category*

When comparing playing styles (offensive vs defensive) in junior women, significant differences ($p<0.05$) in the SJ values have been recorded between attacking vs defensive players (Fig. 6).

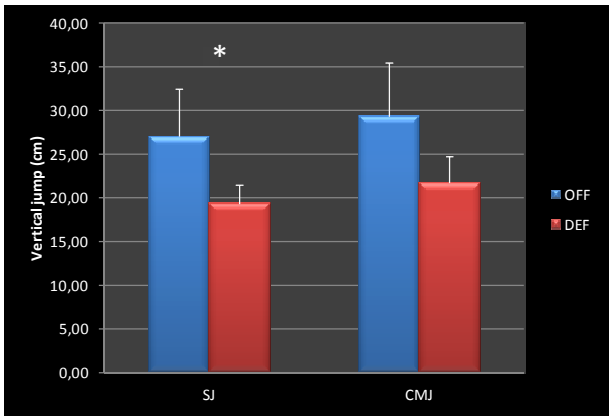

Figure 6. *SJ and CMJ values by playing style (offensive vs defensive).* $p<0.05$*

Offensive style players have higher levels of explosive force that defensive player. These results are related to the specific training performed and to game type adaptation. Offensive game is characterized by fast speed and explosivity, probably due to the higher developement of players muscular mass since a direct relationship between the area of muscle traverse section and indexes force has been highlighted (Bosco, 2000).

Higher explosive force values can be achieved in offensive players as a consequence of their superior capacity of nervous recruitment, the higher levels of FT fibers (type II fibers) and a better reutilization of elastic energy and higher levels of intra- and intermuscular coordination.

4. Conclusions

In prepubertal age no differences exist in the explosive strength between genders. However, it changes significantly in females when starting hormonal development.

The opposing significant differences show a smaller explosivity in the feminine gender than the masculine one, for what the structural characteristics of competition in the masculine individual are different to the feminine individual.

Players with a defensive style show inferior values of explosive force when compared with offensive style players.

High values of explosive force in table tennis, more concretely in the offensive game style, are due to frequent and high efforts required to execute specific displacements with maximum acceleration and speed, that require a very demanding effort of lower limbs, associated with the need of obtaining quick and good positions to hit the ball accurately. It becomes evident that the characteristics of each playing style are different requiring different training planifications.

The SJ and CMJ tests are a good tool for the evaluation of the specific training in table tennis. These data may serve as useful criteria for young

players' selection and for evaluating muscular strength development during training process.

References

1. BOBBERT, F.M., RICHARD, L.J. (2005). Is the effect of a countermovement on jump height due to active state development? *Medicine & Science in Sports & Exercise. 37 (3)*, 440-446.
2. BOSCO, C. (1994). *La valoración de la fuerza con el Test de Bosco*. Barcelona, Paidotribo.
3. BOSCO, C. (2000). *La fuerza muscular. Aspectos metodológicos*. Barcelona, Inde.
4. GONZÁLEZ, J.J. (2002). Concepto y medida de la fuerza explosiva en el deporte. Posibles aplicaciones al entrenamiento, *Revista de Entrenamiento Deportivo. Vol. XIV. 1*, 5-16.
5. GONZÁLEZ, J.L., DÍAZ, N., GARCÍA, L., MORA, J., CASTRO, J., FACIO, M. (2007). Jumping capacity and elasticity index at primary scholar age, *Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte, 7(28)*, 359-373.
6. LARA, A., ALEGRE, M.L., ABIÁN, J., JIMÉNEZ, L., UREÑA, A., AGUADO, X. (2006). The selection of a method for estimating power output from jump performance, *Journal of Human Movement Studies, Vol. 50*, 399-410.
7. PRADAS, F., CARRASCO, L., FLORÍA, P. (2010). Muscular Power of Leg Extensor Muscles in Young Top-level Table Tennis Players. *International Journal of Table Tennis Sciences, 6*, 178-180.
8. PRADAS, F., DE TERESA, C., VARGAS, M.C. (2005). Evaluation of the explosive strength and explosive elastic forces of the legs in high level table tennis players, *Sport Science Research, 3*, 80-86.
9. PRADAS, F. RAPÚN, M., MARTÍNEZ, E., CASTELLAR, C., BATALLER, V., CARRASCO, L. (2012). An analysis of jumping force manifestation profile in table tennis, *International Journal of Table Tennis Sciences, 7*, 19-23.