VERTICAL JUMP CHARACTERISTICS AND LOWER LIMBS MUSCULAR CONTRIBUTION IN CHILEAN VOLLEYBALL PLAYERS DURING THE COUNTER MOVEMENT JUMP (CMJ).

Fábio Dal Bello[1], Enrique Navarro Cabello[2], Javier Rueda[2], Esteban Aedo Muñoz[3]

Physical Activity and Sports Science Master Program, Universidad Santo Tomás, Santiago, Chile[1]
Biomechanics Laboratory, Universidad Politécnica de Madrid, Madrid, España[2]
Biomechanics Department, Chilean High Performance Center, Santiago, Chile[3]

The purpose of this study was to determine and to compare characteristics of the lower limb extension musculature in Chilean indoor and beach volleyball players and the muscular contribution during the CMJ. The sample was composed by 13 subjects belonging to the Chilean elite beach and indoor volleyball. The subjects performed 3 CMJ jumps for average determination of the height of the jump, eccentric force development rate (TDFE), concentric force development rate (TDFC), power and lower limbs muscular contribution, evaluated using force platform and wireless electromyography (EMG). The results demonstrated a significant relationship between the height of the jump-TDFC and power-TDFC and Medial vasti muscle has obtained the most significant contribution during the CMJ in volleyball players.

KEY WORDS: Counter movement Jump, Volleyball Biomechanics, EMG, Muscle activity.

INTRODUCTION: Volleyball is one of the sports that spark most interest of the public and the press around the world, in its indoor and outdoor version. It increasing technician-tactics evolution has captured the interest of technical personnel and researchers, to improve the strategies of training and to increase the performance of athletes (Quiroga et al, 2014). Likewise, it is considered one of the most explosive and rapid sports, due to the fact that its execution contemplates the development of activities that need force, power, agility and speed (Gutiérrez, 2013). The motion requirements most used in volleyball are direction changes and jumps (Bogdanovic et al, 2014), providing a rapid and dynamic game, which is evinced by the fact that most coveted players by professional teams are those that jump the most and finish off with most power. Considering this, jumping becomes one of the most important actions in the development of a game (Ferragut, Cortadellas, Arteaga y Calbet, 2003). A lot of vertical jump information can be obtained across the accomplishment and evaluation of the CMJ, in which parameters as the variables of time, force, the correlation between both (ratio of development of force, impulse and power) and the electromyography variables. This information allows trainers and researchers to understand the subjects characteristics jump and, more specifically, the different phases of the movement (eccentric and concentric) (Cormie, McGuigan and Newton, 2011). Based on the technical and tactical differences existing in the practice of the beach and indoor volleyball modalities, the aim of this study was to determine and to compare the muscular contribution of the gluteus maximus, rectus femoris, medial vasti and medial gastrocnemius across the electromyographic characteristics of the extend musculature of the lower limbs, analyzed during the CMJ in Chileans selected beach and indoor volleyball players.

METHODS: The sample was composed by 13 male subjects, over 18 years belonging to Chilean teams of indoor and beach volleyball. 6 subjects belonging to the beach volleyball branch and 7 belonging to the indoor volleyball branch were selected. Due to the fact that the sample corresponds to elite players, the subjects continued with their normal daily trainings continuing the regime determined by their trainer.

Table 1
General sample averages information

	N	Age (years)	Height (cm)	Body mass (Kg)
Indoor	7	25,5	191,1	84,85
Beach	6	22	188	83,5

The subjects were evaluated in a single measurement. The evaluation meetings were initiated by a brief explanation of the study and its procedures. This was accompanied immediately by a standardized protocol of warming that consisted of 10 minutes of static bicycle and 10 minutes of elongation exercises. After the warming, the subjects were acquainted with the jump protocol (CMJ) and performed 2 sub-maximum practices before realizing the official evaluation test. The evaluation procedure consisted of every subject performing 3 CMJ jumps with 1 minute of rest between them. The subjects were instructed to jump as high as possible, respecting the protocol of CMJ vertical jump. For validity, it was considered the visual execution analysis and the EMG parameters. The gathered information was: height of the jump (h), eccentric force development rate (TDFE – In Newtons per second), concentric force development rate (TDFC - in Newtons per second), power (W), muscular activation, evaluated for wireless EMG, of gluteus maximum (Gl), femoral rectum (RF), medial vasti (VM) and medial gastrocnemio (GM). To establish the real contribution, in percentage of activation, the Manual Voluntary Maximum Contraction (CVMM) was carried out in every muscular evaluated group, in all the subjects.
The information relating to the correlation between the height of the jump and the TDFE, TDFC and W were analyzed by Pearson's correlation statistics. For analysis of comparison between groups, for electromyography variables, the U of Mann-Whitney test was used, and test of medians, due to the size of the sample.

RESULTS: Table II shows that the muscular contribution of the vast medial, during the CMJ, is higher in both modalities of the volleyball. Nevertheless, the information with major relevance is the contribution of the VMD in the indoor players, with 40.16 % of the total of the CVMM of this muscle, with a standard deviation of 5.69. The average values of minor muscular contribution were demonstrated in the gluteus musculature in both volleyball modalities, comparing with the CVMM of this muscular group. In general terms, and considering the specific CVMM of every muscular group, the muscular groups that reached best contributions during the CMJ were the VM and GM. It is possible to demonstrate that for none of the muscular evaluated groups statistically significant values were found.

Table II
Muscular contribution during CMJ (% of CVMM)

Modality	GID	GII	RFD	RFI	VMD	VMI	GMD	GMI
Indoor	31,9	23,4	33,1	29	40,1	32,4	32,8	38,3
Sd	13,5	11,0	11,1	5,6	5,6	10,3	9,9	8,7
Beach	28,8	24,8	24,8	35	30,5	37,8	30,7	34,6
Sd	9,9	9,8	10	20,4	12,6	18,1	7,1	10,1
U de Mann-Whitney	18	18	13	21	10	19	17	15
p	0,6	0,6	0,2	1	0,1	0,7	0,5	0,3

GID: Right Major Gluteus; GII: Left Major Gluteus; RFD: Right Femoral Rectum; RFI: Left Femoral Rectum; VMD: Right Medial Vasti; VMI: Left Medial Vasti; GMD: Right Medial Gastrocnemio; GMI: Left Medial Gastrocnemio; Sd: standard diversion

Table III presents the descriptive information of height of the vertical jump, TDFE, TDFC and Power. Is observed that the subjects of the beach volleyball modality jump, in average, 8.5 % more than the indoor volleyball players. The TDFE appears very similar after having analyzed both groups, being the 22.95 standard deviation, indicating that the indoor volleyball players present major homogeneity in this variable. Likewise, it can be observed that the TDFC is considerably higher in the indoor Volleyball branch. Nevertheless, in this case, the standard deviation appears higher, if the same information is compared to the subjects of the beach modality. The same situation is observed for the power variable, with values relatively more expressive for the indoor branch, also presenting major standard deviation than the beach branch, showing a wider range of values between minimum and maximum in the players of this branch of volleyball.

Table III.
Descriptive average information

Modality	N	h (cm)	TDFE (N/s)	TDFC (N/s)	W
Indoor	7	39,6	84	-264,9	2395,5
Sd		5,7	22,9	28,24	339,46
Beach	6	43	83,4	-24452	2227,6
Sd		6,15	31,3	20,44	192,87

DISCUSSION: The results of this study indicate that significant differences are not observed, in any of the muscular groups, on the muscular contribution compared during the CMJ in beach and indoor volleyball players. A study developed by Yeow et al., (2011) with 10 healthy subjects to evaluate the dissipation of loads during jumps has demonstrated that the pelvic structure, in relation to the femoral joint, generates a dissipation of loads of around 35% during the jump using both legs and 42.9% during the jump using one leg; the knee articular and muscular structure contributes in 35.3% to the dissipation of loads during the two-leg jump while in the one-leg jump found 11.4%; and in the structure of the ankle was found an average of 29.7% of dissipation of loads when the subjects jumped with 2 legs in the soil and 45% in the jump with one leg. These evaluations were registered during the jump, in a sagittal plan of evaluation, and demonstrated that during the two-leg jump, the articular and muscular contribution on the dissipation of loads is similar, with slight relevance for the pelvic structures and knee, whereas the pelvic and ankle structures have major importance during the one leg jump. In another studies, carried out by Mokhtarzadeh, et al. (2013) and Hewett, et al. (2005), the contribution of the soleus and gastrocnemius was analyzed on the anterior crossed ligament (LCA) during the one leg jump and demonstrated that the soleus reaches 28-32 % during the jump, having a significant load on the LCA and that gastrocnemius and soleus have an important role in the agonist and antagonist functions during the vertical jump, considering these two muscular groups determinants on the prevention of LCA's injuries.

Some studies carried out with healthy subjects to evaluate the force, muscular work and power of exit during the vertical jump demonstrated that the vast medial realizes major force and work during the jump accompanied by the gluteus maximum, femoral rectum and gastrocnemius. The authors also demonstrated that the single joint muscular groups contribute considerably more during the jump when compared with bi-articulated muscles and that the adductors, abductors and external rotators being always activated, though their mechanical contribution during the jump work is minor (Nagano, Komura, Fukashiro and Himeno, 2004; Yeow, et al., 2009).

CONCLUSIONS: It is possible to conclude that the muscle groups that have made the most contributions during the vertical jump of the CMJ were the medial vast and medial gastrocnemius. However, in the present study, no statistically significant differences were observed in these variables, when compared between the groups. It is also concluded that there is a close relationship between the height of the vertical jump of volleyball players and TDFC, during the execution of the CMJ, showing no statistical correlation differences with the TDFE and Power variables.

REFERENCES:

Bogdanovic, Z.; Smajic, M.; Jaksic, D.; Milosevic, Z.; Obradovic, B.; Gogic, A.; Vidakovic, H. M.; Ljubisavljevic, M.; Draskovic, V.; Visnjic, S.; Mekic, H.; Stankovic, R.; Ivancic, G. & Popovic, S. Lumbar and abdominal muscles isometric potential in volleyball cadets. *Int. J. Morphol., 32(3)*:1036-1042, 2014.

Cormie, P, McGuigan, MR, y Newton, RU. Developing maximal neuromuscular power: Part 1- Biological basis of maximal power production. *Sports Med* 41: 17-38, 2011.

Ferragut, C, Cortadellas, J, Arteaga, R, y Calbet, J. Predicción de la altura de salto vertical. Importancia del impulso mecánico y de la masa muscular de las extremidades inferiores. *Motricidad: revista de ciencias de la actividad física y del deporte, 10*: 7-22, 2003.

Gutiérrez, G. Perfil de la potencia anaeróbica en jugadores (as) de voleibol juvenil. *Revista da Faculdade de Educação Física da UNICAMP* 11(1): 1-15, 2013.

Hewett, TE, Myer, GD, Ford, KR, Heidt, RS, Colosimo, AJ, McLean, SG. Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes. *American Journal of Sports Medicine*, 33, 492–501, 2005.

Mokhtarzadeh, H, Yeow, CH, Hong Goh, JC, oetomo, D, Malekipour, F y Vee-Sin Lee, P. Contributions of the soleus and gastrocnemius muscles to the anterior cruciate ligament loading during single-leg landing. *J of Biomechanics* 46: 1913-1920, 2013.

Nagano, A, Komura, T, Fukashiro, S y Himeno, R. Force, work and power output of lower limb muscles during maximal effort countermovement jump. *J Electromyo and Kin* 15: 367-376, 2004.

Quiroga, M. E.; Sarmiento, S.; Palomino, A.; Rodríguez-Ruiz, D. & García-Manso, J. M. Características antropométricas de los jugadores españoles de voley playa. Comparación por categorías. *Int. J. Morphol., 32(1)*:22-28, 2014.

Yeow, CH, Vee-Sin Lee, P, Hong Goh, JC. An investigation of lower extremity energy dissipation strategies during single-leg and double-leg landing based on sagittal and frontal plane biomechanics. *Human Mov Sci* 30: 624-635, 2011.

Yeow, CH., Lee, PV, Goh, JC. Regression relationships of landing height with ground reaction forces, knee flexion angles, angular velocities and joint powers during double-leg landing. *Knee*, 16, 381–386, 2009.