Biological Forum – An International Journal **8**(1): 113-117(2016)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Functional Asymmetry of Lower Limbs in Female Elite Volleyball Players during Jumping - landing

Doroudian Zohreh* and Jamshidi Ali Ashraf**
**College of Physical Education and Sport Sciences,*
Central Tehran Branch, Islamic Azad University, Tehran, Iran
***College of Rehabilitation Sciences,*
Iran University of Medical Science, Tehran, Iran

(Corresponding author: Doroudian Zohreh)
(Received 16 December, 2015, Accepted 21 January, 2016)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Introduction: kinetic symmetry of joints is effective in quality of implementing sport techniques and injury prevention. This issue is more important in lower limbs. The present study aimed to investigate symmetry in biomechanical and kinetic variables in lower limbs of elite female volleyball players during jumping - landing. The statistical population consisted of 12 female elite volleyball players of Iranian national team. Ankle, knee and thigh joint torques were measured using movement analysis system (camera and force plates) and calculated using inverse dynamics method. For this purpose, movement analysis system data and force plate data were integrated with anthropometric data and joint torques were estimated using a biomechanical model. The two legs were compared using paired t-test. Asymmetry was calculated using the following formula: the difference between superior leg and inferior leg divided by superior leg multiplied by 100. Maximum values of kinetic parameters (ankle, knee and thigh torque) represents functional asymmetry of lower limbs in female elite volleyball players during jumping - landing. However, minimum values of kinetic parameters show functional asymmetry of lower limbs mostly in middle phases among volleyball players. There was no possibility of professional bodybuilding for these players due to low general physical fitness and possibility of injury and the short intended time for preparing for Asian Tournament. Thus, asymmetry in superior and inferior limb muscular strength was inevitable, which consequently led to unequal force of superior and inferior legs during jumping - landing, which resulted in difference in asymmetry in torques of superior and inferior limbs. However, athletes do not usually force themselves to land on two legs after jumping in defense technique, so that force of landing would be equally distributed on two legs with higher and equal flexion in terms of symmetry.

Keywords: kinetic symmetry, jumping-landing, lower limbs, volleyball

INTRODUCTION

Jumping - landing task is performed by most athletes in many sports (soccer, basketball, volleyball, etc.) in different forms (Devita, 1992). Based on practical experience of coaches, asymmetry in superior and inferior limbs damage or reduce functional quality of volleyball players. Left and right limbs completely move symmetrically in volleyball defense technique.

In a recent study, academics compared asymmetry in ground reaction force in the first and second jump in triple jump in 28 male players and 30 female players. They showed that jumping and impacts on ground reaction force singularly depend on right and left limbs (Benjanuvatra, 2013). In another study, academics studied reliability of different variables of dynamics of symmetry in triple jump in 12 Brazilian female volleyball professional players. The results showed that asymmetrical differences due to maximum force and impact on two force plates is more reliable than asymmetrical differences due to maximum power (Hans *et al.*, 2012).

Raqual *et al.* (2011) also studied asymmetry in lower limbs during jumping in four professional female athletes of Brazilian national volleyball team who were Olympic champions. They showed that a physical training regime can minimize asymmetry, which consequently reduce common injuries among athletes with the aim of preventing possible injuries (Raqual *et al.*, 2011).

Golik-Peric (2011) studied short-term effects of isokinetic exercise versus isotonic exercise in muscular strength asymmetry in 38 different athletes.

It was shown that IT protocol changes muscular function. Furthermore, asymmetrical recycling is very effective for balancing (Golik-Peric *et al.,* 2011). Impellizzeri *et al.,* (2007) examined force in vertical jump to assess bilateral power asymmetry among 451 athletes. They showed that bilateral power asymmetry with VJFT is valid and reliable, which is useful in sports medicine.

Appropriateness of symmetry of lower limbs in quality of implementation of volleyball defense techniques can be used as an efficient and applicable model for scouting and proper planning for bodybuilding and type of volleyball training techniques for coaches. However, this was applied to female volleyball players. For this purpose, we attempted to fill this gap and examine this issue among elite female volleyball players. The main problem lied in investigation of asymmetry in superior and inferior lower limbs in terms of jumping - landing in volleyball defense technique.

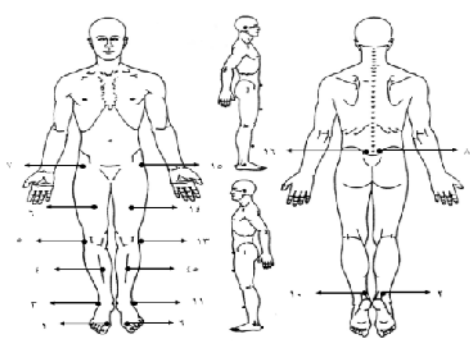
MATERIALS AND METHODS

Performance of superior and inferior legs of the individuals was compared during jumping-landing in volleyball defense technique in terms of kinetic parameters (force and torque). The individuals were selected from elite female volleyball players of national Iranian team. Individual movement was evaluated using movement analysis system and two force plates. Then, Excel and MATLAB were used for calculations. Relevant diagrams were plotted. The results were analyzed by SPSS.

In addition, 12 individuals were voluntarily and not randomly selected from 28 female volleyball players in Iranian national team. The volleyball players had experienced no serious lower limb injuries within the last six months. In the first phase and prior to the study, all individuals were tested for shooting to determine the superior and inferior leg. In later stages, Sargent Jump on two legs was performed to determine explosive jump power. One R M Squat Test was used to assess overall status of all individuals to determine the maximum force created by muscles in both legs.

In the first stage, the sixth movement analysis system with infrared camera with 120 Hz frequency manufactured by Vaykan Corporation and force plate device manufactured by Kistler Corporation with 1200 frequency were used to collect kinetic data. In addition, sixteen light reflective markers were used to indicate the desired location for recording information. Movement analysis refers to comparison of sequential still images taken from a moving individual for studying movements. This system is used in sports biomechanics to help athletes to perform sports activities better and more effectively. Force plate or power platform is a specific device used to measure the forces imposed by an object on the ground. These forces are called ground reaction forces measured by a series of sensors on the plate. The applied markers and their location on lower limbs were as follows:

Table 1.



Number	Right foot	Left foot	Number	Variable
1	R, Toe	L, Toe	9	First metatarsal head
2	R, Heel	L, Heel	10	Back heel
3	R, Ankle	L, Ankle	11	Foreign ankle
4	R, Tibia	L, Tibia	12	Middle anterior surface of tibal
5	R, Knee	L, Knee	13	External condyle of the knee
6	R, Thigh	L, Thigh	14	Middle anterior surface of femur
7	R, Asis	L, Asis	15	Anterior superior iliac spine
8	R, Psi	L, Psi	16	Parties fifth lumbar vertebra

Every individual was marked after wearing specific clothes for testing. Each individual stood on the force plate and moved in Z-axis. Positive direction was upward in the laboratory. For dynamic measurements, the participants were asked to perform jumping-landing volleyball defense technique with their maximum power. The technique consisted of four stages. In the first stage, the individuals were motionless and static. Then, they bent their knees (eccentric). In the second stage, both hand and leg levers were opened and explosive force of leg muscles was released (concentric). At the next stage, the individual left the ground and jumped in a fraction of a second. Then, the individual landed (initial contact with the ground) and ground reaction force was distributed on leg muscles by bending the knees (force absorption).

Movement analysis system and force plate data were integrated with anthropometric data using Inverse Dynamic Method. Joint torques was estimated using reverse dynamic biomechanical model.

RESULTS

A significant difference was found between maximum ankle and knee joint torques in eccentric phase of left and right lower limb kinetic jump. No significant difference was found between kinetic variables of lower limb joints in jump eccentric phase. The results showed no significant difference in asymmetry of three ankle, knee and thigh joints in eccentric phase although no difference was found in function of the two organs.

Table 2: Mean and SD of kinetic variables in eccentric phase and paired T-Test.

Variable	Right members	Left members	Statistical data
Maximum torque ankle	1.50 ± 1.49	-5.09 ± 4.63	t_5 = 2.979, Sig = *****0.031
Minimum torque ankle	-13.34 ± 8.13	-11.87 ± 9.05	t_6 = -0.719, Sig = 0.499
Maximum torque Knee	-1.68 ± 1.77	-4.66 ± 4.35	t_5 = 1.898, Sig = *****0.116
Minimum torque Knee	-9.62 ± 5.98	-9.73 ± 7.51	t_5 = -0.789, Sig = 0.466
Maximum torque femur	11.43 – 7.66	14.82 ± 14.56	t_5 = -0.585, Sig = 0.584
Minimum torque femur	-18.94 ± 12.24	-17.12 ± 16.95	t_5 = 0.437, Sig = 0.680

* Significant difference in 0.05

A significant difference was found in maximum knee joint torque between left and right limbs in concentric phase of left and right lower limb kinetic jump. No significant difference was found between other kinetic variables of lower limb joints in concentric phase.

The results showed no statistically significant asymmetry in three ankles, knee and thigh joints in concentric jump phase although there was a difference in function of the two organs.

Table 3: Mean and SD of kinetic variables in concentric phase and paired T-Test.

Variable	Right members	Left members	Statistical data
Maximum torque ankle	85.42 ± 16.96	89.07 ± 46.17	t_{10} = -0.728, Sig = 0.483
Minimum torque ankle	-14.89 ± 8.12	-12.51 ± 6.59	t_{10} = -0.437, Sig = 0.671
Maximum torque Knee	-5.88 ± 4.21	-9.63 ± 6.18	t_{11} = 2.536, Sig = *****0.028
Minimum torque Knee	-115.39 ± 25.09	-114.42 ± 24.04	t_{10} = -0.063, Sig = 0.951
Maximum torque femur	21.76 ± 20.68	20.26 ± 10.93	t_8 = 0.348, Sig = 0.736
Minimum torque femur	-291.80 ± 43.36	-343.87 ± 176.84	t_{10} = 0.968, Sig = 0.356

*Significant difference in 0.05

No significant difference was found in kinetic landing of right and left lower limbs in initial contact with the ground. The results showed a statistically significant difference in asymmetry of ankle, knee and thigh joints although a difference was found in function of the two organs in initial contact with the ground in landing (Table 3). No significant difference was found in in kinetic landing of left and right lower limbs in force absorption phase. The results showed no statistically significant asymmetry in three ankle, knee and thigh joints in force absorption phase in landing (Table 4).

Table 4: Mean and SD of kinetic variables in first contraction phase and paired T-Test.

Variable	Right members	Left members	Statistical data
Maximum torque ankle	76.44 ± 53.57	50.19 ± 21.81	t_{10} = 1.370, Sig = 0.201
Minimum torque ankle	-32.83 ± 14.25	-23.39 ± 21.59	t_{9} = -0.747, Sig = 0.474
Maximum torque Knee	117.29 ± 75.04	110.16 ± 90.08	t_{10} = 0.346, Sig = 0.737
Minimum torque Knee	-73.58 ± 30.89	-56.70 ± 49.69	t_{10} = -0.805, Sig = 0.440
Maximum torque femur	150.27 ± 84.35	157.71 ± 132.72	t_{10} = 0.018, Sig = 0.986
Minimum torque femur	-137.90 ± 55.44	-105.19 ± 73.10	t_{10} = -0.995, Sig = 0.343

*Significant difference in 0.05

Table 5: Mean and SD of kinetic variables in force attraction phase and paired T-Test.

Variable	Right members	Left members	Statistical data
Maximum torque ankle	57.49 ± 21.68	68.84 ± 40.62	t_{8} = -1.251, Sig = 0.246
Minimum torque ankle	-4.04 ± 2.80	-7.13 ± 5.26	t_{7} = 2.176, Sig = 0.066
Maximum torque Knee	29.89 ± 16.79	20.99 ± 15.12	t_{8} = 1.702, Sig = 0.127
Minimum torque Knee	-88.90 ± 34.33	-121.82 ± 95.39	t_{10} = 1.218, Sig = 0.251
Maximum torque femur	45.08 ± 23.52	28.86 ± 27.35	t_{8} = 1.115, Sig = 0.297
Minimum torque femur	-182.35 ± 54.59	-173.35 ± 79.97	t_{9} = -0.093, Sig = 0.928

*Significant difference in 0.05

DISCUSSION AND CONCLUSION

The graphs of minimum and maximum difference in torques between superior and inferior organs in ankle, knee and thigh joints in eccentric and concentric phases and initial contact with the ground and force absorption. Maximum values of kinetic parameters (ankle, knee and thigh torques) represent functional asymmetry of lower limbs of elite female volleyball players during jumping-landing. However, this issue in minimum values shows functional asymmetry of lower limbs in volleyball players mostly in middle phases.

According to the study and the information obtained from bodybuilding coach and laboratory results, asymmetry in torques were due to following reasons: Players of women's Iranian national volleyball team were not at peak of general physical fitness. Thus, professional bodybuilding could not be performed for symmetry in leg muscular strength. Bodybuilding techniques were performed for both legs simultaneously. However, bodybuilding techniques should be singularly performed for legs for equality of strength of superior and inferior legs. Nevertheless, there was no possibility of bodybuilding due to low general physical fitness of volleyball players and possibility of injury and the short intended time for preparing for Asian Tournament. Thus, asymmetry in superior and inferior limb muscle strength is inevitable. As a result, force of superior and inferior legs would be unequal during jumping-landing, which might result in asymmetrical difference in superior and inferior limb joint torques. These issues are also influential in jump height. The asymmetrical difference between torques was more evident in concentric phase when players opened their levers and upward explosive force was created in superior and inferior legs. Asymmetry in the phase of initial contact with the ground depends on landing of each player. Less flexion of joints leads to smaller torque arm and less force and consequently less torque. However, higher flexion of joints leads to larger torque arm and higher force and consequently higher torque. Another reason for asymmetry in the phase of initial contact with the ground and force absorption lies in the issue that players do not force themselves to land on two legs after jumping in volleyball defense technique for asymmetrical forces and equal distribution of forces on two legs with higher and equal flexions in both legs. This also leads to leg joint injuries in volleyball players.

Benjanuvatra *et al.*, 2013 compared asymmetry in ground reaction force in the first and the second long jumps in triple jump. They showed lower limb symmetry in functional assessment of power asymmetry in the first long jump in triple jump. The results of the former study are consistent with the results of present study only in terms of the first jump. However, impact of ground reaction force is due to complex reasons, which causes asymmetry in the next jumps. In other words, the results of second part of the former study are not consistent with the results of the present study. Raqual (2011) studied lower limb asymmetry during jumping in professional female athletes in Brazil's national volleyball team. They showed that a physical training regime minimizes asymmetry. These results are consistent with those obtained in the present study. In other study, forces in vertical jump test to assess bilateral power asymmetry of athletes. They showed that bilateral power asymmetry with VJFT is valid and reliable.

REFERENCES

Benjanuvatra N, Lay BS, Alderson JA, Blanksby BA. (2013). Comparison of ground reaction force asymmetry in one- and two-legged countermovement jumps. *J Strength Cond Res.* **27**(10): 2700-7.

Devita P SW. (1992). Effect of landing stiffness on joint kinetics and energetics in the lower extremity. *Med Sci Sports Exerc*. **24**(1):108-15

Golik-Peric D, Drapsin M, Obradovic B, Drid P. (2011). Short-Term Isokinetic Training Versus Isotonic Training: Effects On Asymmetry In Strength Of Thigh Muscles. *J Hum Kinet*. **30**: 29-35.

Hans JM, Andre Perreira de A, Fabiola B. (2012). Reliability of Symmetry Differences of Dynamic Variables During Countermovement Jump. *30 th Annual Conference of Biomechanics in Sports*. 327-30.

Impellizzeri FM, Rampinini E, Maffiuletti N, Marcora SM. (2007). A Vertical Jump Force Test for Assessing Bilateral Strength Asymmetry in Athletes. *Med Sci Sports Exerc*. **39**(11): 2044-50.

Raqual C, Maria Isabel VO, Cristina A, Andreia M, Edison DJM, Jose EP, Marcos D. (2011). Asymmetries Between Lower Limbs During Jumping In Female Elite Athletes From The Brazilian National Volleyball Team. *Portuguese Journal of Sport Sciences*. **11**(2): 53-56.