Journal of Advanced Sport Technology 6(1): 9-18.

Received: May, 01, 2022 *Accepted: June. 15, 2022*

Original Research

Comparison of Dynamic Parameters of Landing from Different Heights of Professional Elite Volleyball Players

Farzaneh Shokrian [1], Davood Khezri[2*], Hasan Matin Homaei[3], Ali Fatahi [4]

1. *Department of Sports Biomechanics, Central Tehran Branch, Islamic Azad University, Tehran, Iran. Email:Farzaneh.shokrian@gmail.com, ORCID: 0000-0003-2991-5944.*
2. *Department of Biomechanics and Sports Technology, Sport Sciences Research Institute, Tehran, Iran. Email: daividkhezry@gmail.com, ORCID: 0000-0001-7160-829X.*
3. *Department of Sports Physiology, Central Tehran Branch, Islamic Azad University, Tehran, Iran. Email:hasanmatinhomaee@gmail.com, ORCID: 0000-0001-9340-1759.*
4. *Department of Sports Biomechanics, Central Tehran Branch, Islamic Azad University, Tehran, Iran. Emaol: fattahiali81@gmail.com , ORCID: 0000-0002-8863-4061*

ABSTRACT

This study aims to compare the dynamic parameters of professional elite volleyball players when landing from different heights. 15 volleyball players selected based on availability participated in the study. The studied skill for different height was set to a percentage of the maximum jump elevation (100% - 75% - 50%). A repeated measures ANOVA model was used to determine the measurements variance differences using SPSS software version 24. The results showed that landing from higher height increased the angular velocity of the rotational axis of the foot while the peak of angular acceleration was lower at the highest elevation. The linear velocity peak also showed lower values at the highest elevation, while the linear acceleration increased with increasing landing elevation. Despite the insignificant effect of different height on the vertical ground reaction force (vGRF) factor, the peak of ankle joint torque in the anterior-posterior axis increased with increasing elevation. Similarly, the maximum ankle angle in the anterior-posterior axis was higher at high elevation than at low elevation. The results showed that volleyball players try to improve the absorption of energy by increasing the range of motion of the ankle joint in the anterior-posterior axis at high elevation.

Keywords: Landing Biomechanics, Kinetics, Kinematics, Ankle joint, Volleyball

Corresponding Author: Davood Khezri, Department of Biomechanics and Sports Technology, Sport Sciences Research Institute, Tehran, Iran. Email:daividkhezry@gmail.com, Tel: +989120549811

INTRODUCTION

Volleyball is a non-collision sport, but performing repetitive high intensity movements has defined this sport as a sport with a relatively high prevalence of injury and more than 30% of musculoskeletal injuries [1]. Volleyball athletes need to move fast and score points with long jumps, precise dives, and sudden rerouting; for this reason, the possibility of lower limb injury is evident during displacements, jumps, and landings [2].

Landing following a jump can cause a force of impact 2 to 12 times the body's weight and is often a factor in lower limb injuries [3]. One-legged landing is a common occurrence in sports such as basketball, volleyball, football, and badminton [4]. In the jump-landing movement, the landing stage puts far more pressure on the body than the jumping stage [5]. Studies show that, on average, 60 repetitions of the jump-landing technique are performed per hour of volleyball, followed by a vertical ground reaction force (vGRF) equivalent to one to five times the bodyweight on the lower limb [6]. Since landing is one of the key basic skills in volleyball, examining kinetic factors to prevent injury and improve performance is of utmost importance.

Furthermore, examining the kinematic changes in the joint can be a good measure of the joint being in a high-risk position. On the other hand, related kinematic and kinetic parameters are affected by and related to each other. Therefore, the larger the kinematic changes of the joint, the greater the forces acting on it [7]. Ali et al., (2014) studied the kinematics and kinetics of one-legged landing from different heights and reported that the knee flexion angle in the sagittal plane, trunk flexion angle, and ground reaction force increase significantly with increasing landing elevation [8]. Basically, various aspects in the kinematic and kinetic evaluation of the ankle joint, especially in preventing injury and improving performance, have been considered by researchers, including stiffness [9], joint speed and angle [10], range of motion [11], acceleration [12], torque [12] and joint strength [13].

Kinematic and kinetic changes of jump and landing are affected by the intensity of the jump [14,15]. Volleyball players have to have different jump intensity depending on their playing position changes. Thus, players must adjust their jump intensity according to the team strategy to receive the ball on the net, spike, or block. Therefore, jump elevation is one of the essential and influential factors in the biomechanical analysis of landing. However, up until now, the dynamic changes of jumping at different heights have not been sufficiently examined.

52% of volleyball players experience one or more injuries during a season [16]. Due to this high prevalence rate, it is important to investigate the risk factors for injury since most of these injuries occur when landing from different heights post jump. It is also necessary to fully understand the dynamic mechanisms of landing when jumping from a different height to improve performance. Therefore, the present study aimed to compare the dynamic parameters of professional elite volleyball players when landing from different heights.

MATERIAL AND METHODS

Subjects of the present study were 15 healthy male volleyball players with a mean age of 18.23±2.3 years, a height of 183 ±6.3, a weight of 64.72±14.12 kg, and 3 to 5 years of experience in national competitions, selectively chosen based on availability. After a complete explanation of the research objectives and the method of implementation, the players' consent to participate in this research was obtained. This research has an ethics code number IR.SSRC.REC.1399.141. A force plate (Kistler, 1000 HZ) was used to record kinetic information. This device was installed in the middle of the 20-meter runway, invisible to the participants. Four cameras (japan, JVC, 200 Hz) were parachuted around the force screen for 3D evaluation. Passive markers (10 mm, made in Germany) were used to form the body system. Anatomical markers to determine the kinematic model of the ankle joint included 10 inactive markers with dimensions of 22 mm made in Germany. They were attached to the landmark of the first metatarsal, the fifth metatarsal, second toe, heel, medial and lateral malleolus, medial and lateral epicondyle, and the three-point cluster. After static imaging, the first metatarsal markers, fifth metatarsal markers, heel, and three-point cluster remained as tracking markers on the subject's body. Prior to the start of the running test, the reference coordinates were imaged by all cameras using a labelled cube with the force plate placed in the center of the reference coordinates. The video camera was then synchronized with the force screen. The beginning and end of the movement were determined using a force plate by applying a force of 5N [17]. To use the camera data recorded, the raw data was filtered through MATLAB software, version 2013, using Butterworth second-order zero-lag low-pass method at a cut-off frequency of 45. Cut-off frequency was determined using the residual analysis technique for kinematic and kinetic data. Subjects first performed individual warm-ups, including jogging at an optional speed and landing from a 30 cm box. The maximum jump of the subjects was measured using the Sargent jump test. Then, 50, 75, and 100 percent of the maximum jumps of each subject were calculated. Accordingly, the box elevation was determined for each subject in three landings. Then, after the rest interval, the landing motion test was performed. The elevation of the box was determined according to the percentages obtained from each Sargent test (the box was made with iron bars in such a way that it can be adjusted in elevation) (Figure 1 and 2), then each participant jumped 3 times from each elevation in 3-minute intervals between individual jumps so that after landing, the subject's foot was on the force plate. Using the Cardan-Euler angles system, the angles of the limbs in each of the three-dimensional planes were calculated. Peak moment variables, ground reaction force peak, ankle peak force, linear velocity peak, linear acceleration peak, angular velocity peak, angular acceleration peak, equilibrium time, and peak range of motion of the ankle joint were calculated and used for statistical measures. All steps of statistical analysis were performed using SPSS software version 24. Shapiro-wilk test was used to assess the normality of data distribution. Similarly, repeated measures analysis of variance was used to determine the differences between the measurements, and the Bonferroni post hoc test was used to determine the differences within the group. All stages of statistical tests were evaluated and performed at the significance level of $P \leq 0.05$.

Figure 1. Static state in 50, 75, 100% height

Figure 2. Landing from 50, 75, 100% height

RESULTS

The results of statistical analysis showed that the peak torque of the ankle in the sagittal (P = 0.005) and horizontal (P = 0.003) plates in landing from three different heights are significantly different (Table 1). Similarly, maximum ankle angle in sagittal plates (P = 0.017) and minimum (P = 0.044), peak angular velocity of ankle in frontal plates (P = 0.000), linear ankle velocity in sagittal plates (P = 0.000) and horizontal (P= 0.025), The linear velocity peak of the foot in the sagittal (P = 0.039), frontal (P = 0.000) and horizontal (P = 0.029) planes in landing from three different height are significantly different (Table 2). Finally, the linear acceleration peak of the ankle in the horizontal plates (P = 0.003), the linear acceleration peak of the foot in the sagittal plates (P = 0.008), the frontal (P = 0.003) and horizontal (P = 0.018), the linear peak acceleration of the shank (crus) in the horizontal plates (P = 0.033), peak angular acceleration of ankle in sagittal plates (P = 0.004), peak angular acceleration of foot in sagittal plates (P = 0.015), frontal (P = 0.003) and peak angular acceleration of shank in sagittal plates (P = = 0.016) was significantly different between three landings from different height (Table 3). Due to the large volume of statistical data, kinematic and kinetic parameters that did not show significant differences due to landing from different heights were not reported.

Table (1). Mean, standard deviation, parameters related to lower limb joint torque at landing from three different heights

Variable	Maximum Elevation %	Standard mean and variance	Intragroup p-value	Effect Size (eta^2)	Bonferoni test p-value	
Peak ankle torque – Saggital (Nm/BW)	50	0.36 (0.3)	* 0.005	0.32	50-75	+0.022
	75	0.89 (0.63)			75-100	+1.00
	100	0.85 (0.47)			50-100	+0.011
Peak ankle torque – Horizontal (Nm/BW)	50	0.08 (0.07)	* 0.003	0.38	50-75	+0.017
	75	0.2 (0.12)			75-100	+0.021
	100	0.1 (0.01)			50-100	0.827

*P ≤ 0/05

Table (2). Mean and Standard deviation of parameters related to angular displacement, linear and angular velocity of lower limbs in landing from three different heights

Variable	Maximum Elevation %	Standard mean and variance	Intragroup p-value	Effect Size (eta^2)	Bonferoni test p-value	
Maximum ankle angle -Sagittal (dgr)	50	24.46 (6.63)	* 0.017	0.2	50-75	0.499
	75	24.56 (4.69)			75-100	0.443
	100	26.92 (4.6)			50-100	*0.015
Minimum ankle angle- Sagittal (dgr)	50	-14.91 (0.08)	* 0.044	0.25	50-75	0.243
	75	-22.30 (0.17)			75-100	1.00
	100	-23.83 (0.9)			50-100	0.087
Peak angular velocity of the foot- Frontal (rad/s)	50	0.03 (0.15)	* 0.00	0.43	50-75	*0.004
	75	0.08 (0.12)			75-100	1.00
	100	0.08 (0.24)			50-100	*0.005
Peak linear velocity of the ankle- Saggital (m/s)	50	0.02 (0.01)	* 0.00	0.14	50-75	*0.046
	75	0.04 (0.01)			75-100	*0.002
	100	0.01 (0.007)			50-100	0.138
Peak linear velocity of the ankle-Horizontal (m/s)	50	0.037 (0.02)	* 0.025	0.34	50-75	*0.044
	75	0.023 (0.008)			75-100	0.906
	100	0.027 (0.014)			50-100	0.33
Peak linear velocity of the foot – Sagittal (m/s)	50	0.02 (0.018)	* 0.039	0.24	50-75	0.402
	75	0.01 (0.008)			75-100	0.284
	100	0.008 (0.002)			50-100	0.055
Peak linear velocity of the foot- Frontal (m/s)	50	0.182 (0.11)	* 0.00	0.44	50-75	0.317
	75	0.11 (0.08)			75-100	0.011
	100	0.034 (0.01)			50-100	*0.001

Peak linear velocity of the foot- Horizontal (m/s)	50	0.032 (0.02)	* 0.0029	0.22	50-75	*0.042
	75	0.051 (0.02)			75-100	0.946
	100	0.044 (0.01)			50-100	0.289

*P ≤ 0/05

Table (3). Mean and standard deviation of parameters related to linear and angular acceleration of the lower limbs in landing from three different heights

Variable	Maximum Elevation %	Standard mean and variance	Intragroup p-value	Effect Size (eta^2)	Bonferoni test p-value	
Peak linear acceleration of the ankle- Horizontal ($\mathbf{m}/\boldsymbol{s}^2$)	50	0.031 (0.2)	* 0.003	0.34	50-75	0.151
	75	0.64 (0.5)			75-100	* 0.011
	100	0.2 (0.08)			50-100	0.141
Peak linear acceleration of the foot- Sagittal (m/s^2)	50	0.14 (0.08)	* 0.008	0.29	50-75	0.071
	75	0.26 (0.17)			75-100	0.061
	100	0.14 (0.9)			50-100	1.00
Peak linear acceleration of the foot- Frontal (m/s^2)	50	0.12 (0.101)	* 0.003	0.34	50-75	*0.017
	75	0.34 (0.21)			75-100	1.00
	100	0.32 (0.18)			50-100	*0.013
Peak linear acceleration of the foot- Horizontal (m/s^2)	50	0.97 (0.51)	* 0.018	0.25	50-75	*0.038
	75	1.46 (1.24)			75-100	0.367
	100	1.43 (0.99)			50-100	0.419
Peak linear acceleration of the shank (crus)- Horizontal (m/s^2)	50	0.94 (0.35)	* 0.033	0.21	50-75	*0.039
	75	1.75 (1.08)			75-100	1.00
	100	1.53 (1.14)			50-100	0.29
Peak angular acceleration of the ankle- Sagittal (rad/s^2)	50	4.46 (3.54)	* 0.004	0.39	50-75	0.186
	75	8.52 (6.71)			75-100	*0.003
	100	1.69 (1.1)			50-100	*0.045
Peak angular acceleration of the foot- Sagittal (rad/s^2)	50	3.61 (2.48)	* 0.015	0.31	50-75	0.539
	75	5.59 (4.57)			75-100	0.01
	100	1.63 (0.81)			50-100	*0.039
Peak angular acceleration of the foot- Frontal (rad/s^2)	50	1.53 (0.87)	* 0.003	0.34	50-75	*0.042
	75	3.57 (2.1)			75-100	0.45
	100	1.52 (0.87)			50-100	1.00
Peak angular acceleration of the shank	50	2.24 (0.35)	* 0.016	0.28	50-75	0.055
	75	4.32 (3.11)			75-100	0.92

(crus)- Sagittal (rad/s^2)	100	2.69 (1.95)			50-100	1.00

*P ≤ 0/05

Discussion

This study aimed to compare the performance of professional elite volleyball players when landing from different heights using modern kinetic and kinematic methods. The results showed that the height of landing elevation affects the kinematics of the ankle joint and the limbs of the foot and shank in three axes of motion. As the elevation increases, the linear velocity of the ankle joint and foot in the anterior-posterior axis decreases to the maximum extent. Most linear velocity changes occur in the anterior-posterior axis, while linear acceleration changes occur with increasing elevation in all three axes of motion. These results clearly show that the trend of changes in the linear peak velocity and linear acceleration in the ankle joint and foot limb when landing from different heights is not the same.

Research has shown that one of the most important forces on the body when landing is the vertical force of the ground reaction, which is mentioned as an indicator of the risk of injury to the joints of the ankle, knee, thigh and spine [18]. The factors that affect the magnitude of vertical ground reaction force (vGRF) include velocity, landing elevation, shoe type, body weight, position and landing surface, and landing strategy. Increasing the elevation increases the reaction force of the ground and increases the load on the joints [19, 20]. The results showed that the higher the ground reaction force, the higher the torque in the knee joint and the ankle joint; therefore, the amount of damage to these two joints may increase with increasing reaction forces. There is a relationship between the maximum torque of the knee joint and the ankle joint with the maximum ground reaction force. Increased torque increases joint damage. As the ground reaction force increases, the amount of joint torque and, consequently, the amount of load (ROL) on the knee joint and the ankle joint increases. It is likely that as the amount of load applied to the joint increases, the amount of damage to the joint increases as well [21]. In the results of the present study, with increasing landing elevation, the peak torque of the ankle joint increases, which is consistent with the results of De wit et al. (1995), Chappell et al. (2002), and Fattahi et al. (2017).

According to research, with increasing elevation, the reaction force of the ground at the moment of contact also increases; as a result, with increasing landing elevation, the maximum angle of flexion of the knee was observed [22].The relationship between landing elevation and ground reaction force, knee flexion angle, angular velocity, and joint strength during bipedal landing was evaluated. The results showed a direct relationship between ground reaction force and knee flexion intensity with increasing elevation, meaning that increasing the landing elevation increases the ground reaction force and the knee flexion angle [23].The present study was performed by landing on one foot and on the ankle joint. As a result, it is inconsistent with the research of Ali et al. (2014) and Yeow et al. (2009) but is consistent in increasing the joint angle and increasing the angular velocity.

Based on the relationship between work and energy, a decrease in angular velocity can reflect a decrease in energy absorption [24,25]. When the body is being worked, changes in the angular component of the body's kinetic energy occur as an unbalanced torque in a range of motion. On landing, the angular velocity of the joints is also reduced to zero. A peak above angular velocity reflects more angular kinetic energy of rotating objects. More negative work must be done in the form of torque applied in the opposite direction of rotation to reduce the angular kinetic energy to zero. The source of torque to reduce the angular velocity in the ankle is the extraversion activity in the posterior muscles of the ankle. Therefore, there may be a hypothesis that more extrinsic activity of the dorsiflexor muscles is required to reduce the angular velocity of the ankle joint when descending from a higher altitude compared to descending from a lower altitude [26]. A study of kinematics and the kinetics of the ankle joint during landing was conducted to compare the superior foot with the non-superior foot. Subjects performed landing movements from three different heights (0.32 m, 0.52 m, and 0.72 m). This study measured ground reaction force, and ankle joint kinematics, in both Legs. The results showed that the maximum angular velocities of dorsiflexion and abduction are significantly higher in the superior ankle [27]. The findings reported in the present study are consistent with results reported by Niu et al (2011) regarding the increase in angular velocity for landings on the superior foot.

Changes in limb speed and acceleration during landing are significant and can be considered as a cause of injury; for example, anterior cruciate ligament injury is very common in unbalanced landing patterns [28]. As the height increases, the maximum amount of changes in the linear velocity of the ankle joint and limb in the anterior-posterior axis decreases. The results showed that the linear velocity in different axes of motion could vary depending on the landing elevation. The peak of linear velocity in the ankle joint in the rotational axis was achieved at a lower height, while it was achieved at 75% elevation in the anterior-posterior axis. Increasing the landing speed due to high elevation does not necessarily lead to damage if proper landing techniques are used. An increase in changes in vertical velocity is associated with an increase in the vertical ground reaction force [29]. In the present study, the peak of linear velocity was reduced at high elevation. Thus it is inconsistent with the research of Dai et al (2019).

The results showed that for volleyball players, landing from a higher height increases the angular velocity of the foot limb in the rotational axis, increases the peak torque of the ankle joint in the anterior-posterior axis, increases the ankle angle in the anterior-posterior axis, and also increases the peak of linear acceleration. While the peak of angular acceleration and the peak of linear velocity at the highest elevation showed lower values. Therefore, coaches and athletes can use training methods to strengthen the selected ankle muscles by considering the optimal implementation of landing strategies with an injury prevention approach.

CONCLUSION

The results showed that volleyball players try to improve the absorption of energy by increasing the range of motion of the ankle joint in the anterior-posterior axis at high elevation.

Author Contributions: Conceptualization, DKh. and FSh.; methodology, FSh. and AF.; formal analysis, AF. and H-MH.; investigation, DKh and AF.; resources, FSh.; data curation, AF.; writing—original draft preparation, DKh. and FSh.; writing—review and editing, AF.; supervision, DKh. and H-MH.; project administration, FSh. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding. This study was extracted from the Ph.D. thesis of first author at Department of Sports Biomechanics, Central Tehran Branch, Islamic Azad University, Tehran, Iran.

Institutional Review Board Statement: The study protocol was approved by the local ethics committee of Sport Sciences Research Institute (Tehran – Iran).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data will be available at request.

Acknowledgments: We gratefully acknowledge volleyball players that participated in this research. The authors declare no conflict of interest.

References

1- Fattahi A, Sadeghi H, Ameli M. Relationship between injury types and prevalence with some anthropometric properties of male elite volleyball players of Iran. World Appl. Sci. J. 2011;15(5):667-72. (In Persian)

2- Verhagen E, Van der Beek A, Bouter L, Bahr R.M, Van Mechelen W. A one-season prospective cohort study of volleyball injuries. Br J Sports Med. 2004;38(4):477-81.

3- Soleiman Fallah MA, Sadeghi H, Motamedi p, Barati AH. Effect of One Stage of Exhaustive Local Fatigue on Mechanical Parameters of Lower-Limb Joints during the Single-leg Landing of Semi-Professional Sportsmen. J Rehab Med. 2020; 8(4): 177-184

4- Boden BP, Torg JS, Knowles SB, Hewett TE. Video analysis of anterior cruciate ligament injury: abnormalities in hip and ankle kinematics. Am J Sports Med. 2009;37(2):252-9.

5- Chappell JD, YuB,KirkendallDT,Garrett WE. "A comparison of knee kinetics between male and female recreational athletes in stop - jump tasks". Am J Sports Med. 2002; 30; 261–267

6- Bressel E, Cronin J. The landing phase of a jump strategies to minimize injuries. JOPERD. 2005;76(2):30-5.

7- Sigward, S., & Powers, C. M. The Influence of Experience on Knee Mechanics during Side-Step Cutting in Females. Clinical Biomechanics. 2006; 21(7), 740-747.

8- Ali N, Robertson DG, Rouhi G. Sagittal plane body kinematics and kinetics during single-leg landing from increasing vertical heights and horizontal distances: implications for risk of non-contact ACL injury. The Knee.2014;21(1):38-46.

9- Whitting JW, Steele J, McGhee D, Munro B. Effects of passive ankle dorsiflexion stiffness on ankle mechanics during drop landings. Journal of Science and Medicine in Sport. 2012;15(5):468-73

10- Lee M-S, Lee J-H, Park S-K, Kang J-I. The effect of ankle joint taping applied to patients withhemipshankia on their gait velocity and joint angles. Journal of Korean Physical Therapy. 2012;24(2):157-62.

11- An C-M, Won J-I. Effects of ankle joint mobilization with movement and weight-bearing exercise on knee strength, ankle range of motion, and gaitvelocity in patients with stroke: a pilot study. Journal of physical therapy science. 2016;28(2):689-94.

12- Aramaki Y, Nozaki D, Masani K, Sato T, Nakazawa K, Yano H. Reciprocal angular acceleration of the ankle and hip joints during quiet standing in humans. Experimental brain research. 2001;136(4):463-73.

13- Orishimo KF, Burstein G, Mullaney MJ, Kremenic IJ, Nesse M, McHugh MP, et al. Effect of knee flexion angle on Achilles tendon force and ankle joint plantarflexion moment during passive dorsiflexion. The Journal of foot and ankle surgery. 2008;47(1):34-9.

14- Gabriele Wulf & Janets.Dufek Increased Jump Height with an External Focus Due to Enhanced Lower Extremity Joint Kinetics. Journal of Motor Behavior.2009;41(5): 401-9

15- Alberto Fílter. Jesús Olivares Jabalera. Alejandro Molina-Molina. Luis Suárez-Arrones. José Robles-Rodríguez. Thomas Dos'Santos. Effect of ball inclusion on jump performance in soccer players: a biomechanical approach. Science and Medicine in Football. 2021; 6(2): 241-24

16- Augustsson SR, Augustsson J, Thomee R, Svantesson U. Injuries and preventive actions in elite Swedish volleyball. Scand J Med Sci Sports. 2006;16:433-4.

17- Khezri, D., Eslami, M., Yousefpour, R. (2019). Clustering healthy runner based on 3-D kinematics patterns of pelvic during running using hierarchical method. Journal of Applied Exercise Physiology, 14(28), 227-240. doi: 10.22080/jaep.2019.14354.1769

18- Kijowski R, Sanogo ML, Lee KS, Muñoz del Río A, McGuine TA, Baer GS, et al. Short-term clinical importance of osseous injuries diagnosed at MR imaging in patients with anterior cruciate ligament tear. Radiology. 2012;264(2):531-41.

19- Chappell JD,YuB,KirkendallDT,Garrett WE. "A comparison of knee kinetics between male and female recreational athletes in stop - jump tasks". Am J Sports Med. 2002; 30; 261–267

20- De Wit, B., D. De Clercq, and M. Lenoir. The effect of varying midsole hardness on

impact forces and foot motion during foot contact in the running. J Appl Biomech, 1995.11: 395-406

21- Fattahi, f, Sharifnejad A, Karimi MT. The relationship between the maximum torque of the lower limb joints and the maximum vertical reaction force of the ground in a single- legged landing task. Sports Medicine Materials. 2017; 22: 128-101. (In Persian)

22- Ali N, Robertson DG, Rouhi G. Sagittal plane body kinematics and kinetics during single-leg landing from increasing vertical heights and horizontal distances: implications for risk of non-contact ACL injury. The Knee.2014;21(1):38-46.

23- 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. The Knee. 2009;16(5):381-6.

24- Zhang X, Xia R, Dai B, Sun X, Fu W. Effects of exercise-induced fatigue on lower extremity joint mechanics, stiffness, and energy absorption during landings. Journal of sports science & medicine. 2018;17(4): 640 - 649.

25- Lee J, Song Y, Shin CS. Effect of the sagittal ankle angle at initial contact on energy dissipation in the lower extremity joints during a single-leg landing. Gait & posture. 2018;62:99-104.

26- Winter DA. Biomechanics and motor control of human movement: John Wiley & Sons; 2009.

27- Niu W, Wang Y, He Y, Fan Y, Zhao Q. Kinematics, kinetics, and electromyogram of ankle during drop landing: a comparison between dominant and non-dominant limb. Human movement science. 2011;30(3): 614-24.

28- Dai B, Mao M, Garrett WE, Yu B. Biomechanical characteristics of an anterior cruciate ligament injury in javelin throwing. Journal of Sport and Health Science. 2015;4(4):333-40.

29- Dai B, Garrett WE, Gross MT, Padua DA, Queen RM, Yu B. The effect of performance demands on lower extremity biomechanics during landing and cutting tasks. Journal of Sport and Health Science. 2019;8(3):228-34.

مقایسه پارامترهای دینامیکی فرود از ارتفاع های مختلف والیبالیست های نخبه حرفه ای

فرزانه شکریان [۱]، داود خضری*[۲] ، حسن متین همایی [۳] ، علی فتاحی[۴]

۱- گروه بیومکانیک ورزشی، واحد تهران مرکزی، دانشگاه آزاد اسلامی، تهران، ایران

۲- گروه بیومکانیک و فناوری ورزشی، پژوهشکده تربیت بدنی و علوم ورزشی ، تهران، ایران (نویسنده مسئول)

۳- گروه فیزیولوژی ورزشی، واحد تهران مرکزی، دانشگاه آزاد اسلامی ، تهران، ایران

۴- گروه بیومکانیک ورزشی، واحد تهران مرکزی ، دانشگاه آزاد اسلامی ، تهران، ایران

چکیده

هدف از انجام پژوهش حاضر مقایسه عملکرد والیبالیست های نخبه حرفه ای هنگام فرود از ارتفاع های مختلف با استفاده از روش های نوین کینتیکی و کینماتیکی می باشد. ۱۵ والیبالیست به صورت هدف دار و در دسترس در این پژوهش شرکت کردند. مهارت مورد بررسی از ارتفاع های مختلف بصورت درصدهایی از ارتفاع بیشینه پرش (۱۰۰٪ - ۷۵٪ - ۵۰٪) در نظر گرفته شد. از آمار توصیفی برای معرفی میانگین، انحراف استاندارد و آزمون شاپیروویلک برای ارزیابی نرمال بودن توزیع داده ها، از آزمون تحلیل واریانس اندازه‌گیری‌های مکرر جهت تعیین تفاوت بین اندازه‌گیری های انجام شده و از آزمون تعقیبی بونفرونی برای تعیین تفاوت‌های درون گروهی استفاده گردید. تمامی مراحل تجزیه‌وتحلیل آماری با نرم افزار اس‌پی‌اس‌اس نسخه ۲۴ انجام شد. یافته ها نشان دادند که فرود از ارتفاع‌های بالاتر در والیبالیست‌ها سبب افزایش سرعت زاویه‌ای اندام پا در محور چرخشی می‌شود در حالی که اوج شتاب زاویه‌ای در بالاترین ارتفاع کمتر بود. همین‌طور اوج سرعت خطی نیز در بالاترین ارتفاع مقادیر کمتری را نشان داد در حالیکه شتاب خطی با افزایش ارتفاع فرود افزایش یافت. با وجود عدم تاثیر ارتفاع‌های متفاوت بر مولفه نیروی عکس‌العمل زمین اوج گشتاور مفصل مچ پا در محور قدامی-خلفی با بالا رفتن ارتفاع افزایش داشت. همچنین حداکثر زاویه مچ پا در محور قدامی-خلفی در ارتفاع بالا نسبت به ارتفاع پایین بیشتر بود. نتایج نشان دادند والیبالیست‌ها با افزایش دامنه حرکتی مفصل مچ پا در محور قدامی-خلفی در ارتفاع بالا سعی در جذب انرژی بهتر دارند. هم چنین، تغییرات بیشتر در متغیرهای سرعت و شتاب زاویه‌ای در ارتفاع پایین‌تر نشان از انتقال انرژی به اندام‌های بالاتر دارد.

واژگان کلیدی: بیومکانیک فرود ، کینتیک و کینماتیک مفصل مچ پا ، والیبال