Journal of Advanced Sport Technology *8(2):14-26*

Received: May, 20, 2023 *Accepted: March, 23, 2024*

Original Research

The Effect of Four Types of Training: Plyometric, Balance, PNF and Combination Training on Physical Performance and Ankle Injury Prevention in Basketball Players: A Clinical Trial

Banafsheh Mohammadi[1], Nayeb Ahmadpour[2], Mohammad Rabiei[3]

1. Department of Sport Sciences, Faculty of Literature and Humanities, Shahrekord University, Shahrekord, Iran, E-mail: bmohammadi290@gmail.com,ORCID:0000-0001-9951-2265.

2. Department of Sport Sciences, Faculty of Literature and Humanities, Shahrekord University, Shahrekord, Iran, E-mail: nayebahmadpour@gmail.com. ORCID:0009-0000-5407-8063.

3. Department of Sport Sciences, Faculty of Literature and Humanities, Shahrekord University, Shahrekord, Iran, E-mail: md.rabiei@yahoo.com. ORCID: 0000-0002-1710-5058.

ABSTRACT

Basketball accounts for approximately up to 92% of injuries, most of which are reported in the lower limbs, especially in the ankle. The purpose of this study was to investigate the effect of plyometric, balance, PNF and combination exercises on physical performance and prevention of ankle injuries in young basketball players. In this clinical trial with pre-test and post-test of 75 young basketball players aged 16 to 18 assigned to 5 groups of 15 individuals (aged 17.26±0.24 years; height 182.38±11.7 cm; body mass 80.82±3.04 kg; BMI 24.38±1.36 kg.m^2), training groups consisted of plyometrics, balance, PNF and combination (plyometric and balance and PNF), and a group playing basketball without redundant training was considered as control. The physical performance of athletes was checked by measuring strength, endurance, explosive power and range of motion respectively using dynamometer, inclination board, Sargent jump board and electro goniometer before and after the training period, and the number of injuries to the ankle was measured by using a questionnaire with reasonable validity during training and until Six months after the training period. The results showed the increase in dorsiflexion strength in plyometric and combination groups, but the increase in plantar flexion strength occurred only in the combination group, the improvement of ankle endurance was observed in the plyometric and combination groups, the improvement of the range of motion in the combination and PNF groups, and the

explosive power increased in PNF and combination groups. Regarding injury prevention: combination, balance, plyometric, PNF and control groups attained the first to fifth ranks, respectively. One of the important causes of ankle injury among basketball players is insufficient function of ankle muscles. Based on the results, the combination exercises group showed a greater impact on the physical performance and injury prevention of young basketball players than other exercises and therefore can be recommended as a complementary exercise to the main exercises to be included in the athletes' main training program.

Keywords: Basketball, Plyometric Exercise, Balance Exercise, PNF Exercise

Corresponding author: Banafsheh Mohammadi, *Department of Sport science, Faculty of Humanities, Assistant Professor of Sport Biomechanics, Shahrekord University, Shahrekord, Iran. E-mail: bmohammadi290@gmail.com.*

INTRODUCTION

Basketball is one of the most popular sports with 212 member countries and 450 million athletes while the number of young male and female basketball players is increasing every year. According to available reports, about 11% of the world's population plays basketball regularly. However, in this popular game, the injury rate has been reported up to 92% in the lower limb especially in the ankle with repetition rate of around 80% at all skill levels. Research has also shown that ankle sprains are the most common acute musculoskeletal injury at all levels of basketball with other injuries [1].

It is argued that damage to the sensory receptors in the ankle region causes a defect in proprioception, which prevents the central nervous system from accurately understanding the position of the ankle joint in space. This defect subsequently leads to an increased occurrence of giving way to ankle into hyper supination and results in ankle injury because there is no proper response of the peroneal muscles when the ankle is in an incorrect position [2]. For the first time, Freeman et al. (1965) showed that defects in the sensory system were related to ankle sprains [3,4]. Other studies have also shown that people with ankle instability have defects in postural control and balance, and increasing postural fluctuation increases the risk of sprains and ankle injuries [5]. Among the other important causes of injury in the ankle, we can point out the weakness in the strength and range of motion of muscles and ligaments, which causes imbalance when landing or turning the sole of the foot inward (supination) [6]. Studies have shown that damage to the ankle ligaments due to sprains causes a disturbance in the role of feedback and a delay in the reaction time of the ankle muscles, which leads to functional instability with symptoms such as giving way to the ankle, weakness, pain and a defect that is probably accompanied by pain and swelling [5,6]. Chandler PT et al (2018) discussed the importance and value of plyometric exercises and showed that plyometric exercises increased strength, speed and combination both in jumps, and therefore they are referred to as strength exercises [7]. As a result of plyometric training, the athlete will have a faster start, and it has been shown that plyometric exercises play a significant role in

improving strength, feedback time to the stimulus and endurance of the ankle muscles, and also have a significant effect in preventing injury during landing, but It does not have remarkable effect on balance, which is the most important determinant of movement strategies within the closed kinetic chain and improves posture control due to the reduction of fluctuations, increase in strength and flexibility of muscles and ligaments [8].

Hall EA et al. (2018) and Han J et al. (2015) reported that balance exercises would improve the dynamic balance; and performance of athletes, and balance due to the increase in the range of motion of joints and the strengthening of depth sensors in the soles of the feet in many stages play an important role in preventing injury, but it has no effect on increasing the strength and time of feedback to the stimulus and the range of motion of the joint [9,10].

PNF exercises include stretching exercises that are effective on the range of motion, and Alahmari KA et al. (2020) showed that this type of exercises is designed based on neural patterns, and in addition to increasing the range of motion, they reduce spasms and accelerates recovery. Lazarou L et al. (2018) showed that PNF exercises did not have a significant effect on feedback time to the stimulus and ankle dorsiflexion strength [11,12].

It has been shown that plyometric, balance and PNF exercises, which have a significant effect in restoring some functional factors to injured people, do not have an effect in preventing injury and preventing re-injury [13]. Complete and comprehensive special exercises are essential. Combination exercises (plyometric, balance and PNF) as complementary exercises along with the main exercises are likely to lower the injury [14]. Given the above-cited findings and arguments, the purpose of this study was to comparatively investigate the effect of these three types of exercises and their combination on physical performance and the prevention of ankle injuries.

MATERIAL AND METHODS

The present study was conducted as a clinical trial. The study population consisted of all young male basketball players aged 16 to 18 without a history of ankle injury and with two years of basketball sport experiences in the city of Shahrekord, southwest Iran. One-way analysis of variance with 5 groups at a significance level of P=0.05 produces a single comparison error rate of α=0.0125. To produce a power of 0.8 with an effect size of 0.45, the required gross sample size was determined to be 80 participants.

According to the data and using G*Power software with statistical of 0.8, effect size of 0.45 and alpha statistical error of 0.05 and using the ANOVA between 5 groups, the number of samples was determined at 65 individuals. A total of 75 volunteers given the possibility of attrition during the training period were finally enrolled. The samples were all right dominant hand and foot. They were recognized by throwing the ball for the hand and hitting the ball for the foot, respectively. The samples were randomly divided into five groups of 15 people. The inclusion criteria were: male gender, age range of 16-18 years, attending at least two regular training sessions per week, being in the normal range of body mass index, no deformities and no history of ankle sprains during the last 6 months, no history of illness, surgery and orthopedic abnormalities, including the difference of more than 3 mm in the length of the two legs. The exclusion criteria were absence of

three or more time in training sessions, the subject's lack of interest in continuing training, and the occurrence of any joint and muscle injuries during training [15].

The ankle injury was measured first as one of the criteria for enrollment in the study and then immediately after the training period and also six months after the training period using the ankle function evaluation questionnaire. This questionnaire is one of the standard instruments in the field of ankle function evaluation. This questionnaire contains 12 items with 5 options. The maximum overall score of the tool is 104, and a score higher than 34 indicates functional limitations of the injured ankle. The validity of the questionnaire has been reported as being 0.9 [16].

Before starting the study, the purpose and work process were explained to the subjects, then all the studied subjects voluntarily signed the consent form to participate in the study. The subjects were also assured they could withdraw from the study whenever they wished. After performing anthropometric measurements (age, height, weight, BMI), functional factors strength, endurance, power and range of motion were measured by the researcher as pre-test. Then, the experimental groups under the same conditions performed 4 types of training methods (plyometric, balance, PNF and combination) in a time of 30 to 45 minutes in each session in addition to their skill exercises in 3 sessions per week during 8 weeks. The researcher directly supervised the groups. The exercise program of the experimental groups was determined by observing the principle of overload and gradually increasing the duration and repetition of each exercise. According to the training program, plyometric exercises included double-leg and single-leg jumping exercises in length and height, and balance exercises included exercises for maintaining balance in pair-leg and single-leg positions with stable and unstable surfaces and with open eyes and close eyes positions also PNF training included stretching and pressure exercises at different levels and also combination training included plyometric, balance and PNF exercises. Exercises changed from an easy level with low pressure to a hard level with high pressure during eight weeks according to the principle of overload (Table No. 1). The control group simultaneously performed their usual exercises in training sessions. After the training period in experimental groups and control group, the functional factors were measured as post-test by the researcher. For assessing the functional factors in pre-test and post-test, the instruments below were used:

To measure the strength of the ankle muscles, a Takei dynamometer (Japan) to the nearest 0.1 Newton was used in dorsiflexion and plantar flexion movements [17]. For checking leg muscle endurance by means of inclination board test, a slope of 30 degrees and a distance of 45 cm to the wall, and the amount of muscle endurance with the amount of people's ability to bear body weight on the ankle per unit of time and in dorsiflexion mode were considered. This instrument has already been reported to have acceptable validity and reliability (0.9) [18]. An electro goniometer for biometrics with a measurement accuracy of 0.1 was used to measure the range of motion of the ankle in the steering position and the range of motion of dorsiflexion and plantar flexion with acceptable validity and reliability (0.9). The vertical jump power of the subjects was measured by using Sargent's digital jump board with sensor screen with an accuracy of 1 cm, dimensions 40 x 200 cm. In this way, the subjects, while standing on the side, touched the highest spot they could with their superior hand. Then they performed three consecutive jumps with one minute rest intervals, the highest point they reached on the board with their superior hand was recorded for the title of the record. The reliability of this test when the subjects have warmed up well has been reported between (0.90 and 0.99), concurrent validity (0.78) has been reported [19].

The amount of ankle injury was measured immediately after the training course and also six months after completing the course using a questionnaire (IDFAI_Ar)[1]. In this questionnaire, the degree of injury severity based on mild, moderate and severe injury and recovery time based on week and severity of injury in repetitions based on mild, moderate and severe injury were given points (1-15) and also the average pain score in exercise and pain during daily activities were scored (1-15). According to the scoring system table, each factor is scored between 0 and 5, and the influencing factors in the score of each group are the severity of the injury and the time of recovery and return to the main stream exercises, the amount of repetition of the injury, and the type of pain and instability that occurs in the two cases of exercise and daily activity is performed and it was investigated that a lower score indicates a lower probability of injury and vice versa [20].

Table 1. Training protocol of the group

Group	**Type of Training**	Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8
Plyometric	Barrier height	30cm	35cm	40cm	45cm	60cm	50cm	55cm	65cm
	Jump type	Pair foot	Pair foot	Pair foot	Pair foot	Single leg	Single leg	Single leg	Single leg
	Set and repeat	12*3	12*3	12*3	10*4	12*4	10*4	10*4	12*4
Balance	Balance type	Pair foot	Pair foot	Single leg	Single leg	Single leg	Pair foot	Pair foot	Single leg
	Platform type	Constant	Fluctuated	Constant	Fluctuated	Constant	Constant	Fluctuated	Fluctuated
	Eye type	Open	Open	Open	Open	Close	Close	Close	Close
	Set and repeat	S20*3	S20*3	S20*3	3*20 S	3*10 S	3*10 S	3*10 S	3*10 S
PNF	Stretch type	Static	Static	Static	Static	Dynamic	Dynamic	Dynamic	Dynamic
	Pressure type	Non active	Non active	Active	Active	Active	Active	Non active	Active
	Set and repeat	S20*3	S20*3	S20*3	S20*3	S20*3	S20*3	S20*3	S20*3
Combination	Barrier height	30cm	35cm	40cm	45cm	60cm	50cm	55cm	65cm
	Jump and land on platform	Pair foot Constant	Pair foot fluctuated	Single leg fluctuated	Single leg Fluctuated	Pair foot Constant	Pair foot fluctuated	Single leg constant	Single leg constant
	Set and repeat	2*15	2*15	2*15	2*15	3*15	3*15	3*15	3*15
	Stretch pressure type (PNF)	Static active (20s)	Dynamic active (20s)	Dynamic non active (20s)	Dynamic active (20s)	Dynamic non active (20s)	Static non active (20s)	Dynamic active (20s)	Dynamic active (20s)

[1] Identification of functional ankle instability

This study was obtained from a student's thesis and its protocol was approved by the Research Ethics Committee of Shahrekord University (IR.SKU.REC.1400.075).
In this study, Excel version 26 software was used to enter and sort data and draw graphs and SPSS version 23 was used for data analysis. First, the Shapiro-Wilk test was used to evaluate the normality of the data. To investigate intragroup and intergroup changes, parametric ANOVA and Tukey's test were used, and for more detailed analysis, pre-test and post-test differences were calculated for each group, and intragroup comparisons were conducted based on this difference. In this study, the significance level ($P \leq 0.05$) was considered.
According to the table (1) is dedicated equal time for training in addition to practicing basketball for each group and per group had the same time for doing their own practice in the warm-up section of training session and then were commencing to doing basketball training.

RESULTS

Demographic characteristics of the subjects in table (2), the information related to the body measurement indices of the participants can be seen and according to the Shapiro–Wilk test there was no significant difference between the studied groups ($P \geq 0.05$).

Table 2. Demographic characteristics of the subjects

Variable	Plyometric M ± SD	Balance M ± SD	PNF M ± SD	Combination M ± SD	Control M ± SD
Age (y)	17.8±0.6	17.3±0.2	17.5±0.4	17.4±0.1	17.1±0.5
Height(cm)	182.2±10.4	181.9±10.6	183.0±13.2	182.6±10.8	182.2±13.5
Weight(kg)	81.1±3.9	79.9±4.1	82.8±2.2	83.0±3.1	77.3±1.9
BMI (kg/m^2)	24.4±1.2	23.6±0.9	24.6±1.1	24.9±2.2	24.4±1.4

The difference between the pre-test and post-test scores was used by the ANOVA statistical test to measure different functional factors. If there was a significant difference between the groups, Tukey's test was used to conduct inter-group comparisons.
ANOVA test in measuring strength of ankle in dorsiflexion and plantar flexion with using the difference (Δ) of pre-test and post-test scores did not show a significant difference between groups ($p>.05$) but the paired t-test in each group compared the pre-test scores. The pre-test and post-test showed the significance in plyometric group and combination group in the strength of ankle dorsiflexion muscles and the significant effect in the strength ankle plantar flexion was seen in combination group (Table 3).

Table 3. Results on ankle muscle strength

Variable	Group	Pre test M± SD	Post test M± SD	Difference (Δ) Pre-test and post-test	Df	F	*P value between-group

Dorsi flx (N)	Plyometric	29.84±1.81	31.16±1.82	1.96±1.32	4	0.89	0.48
	Balance	24.56±2.01	25.21±2.44	5.50±0.65			
	PNF	31.47±3.11	32.81±2.36	4.90±1.33			
	Combination	30.66±0.16	33.92±0.96	2.57±3.24			
	Control	28.14±1.03	29.66±1.32	3.80±1.52			
Plantar flx (N)	Plyometric	55.19±1.47	55.81±1.45	4.84±0.62	4	1.43	0.23
	Balance	52.86±2.19	54.83±1.16	3.80±1.97			
	PNF	56.91±2.22	57.74±3.01	5.57±0.83			
	Combination	52.71±1.01	55.37±2.23	4.91±2.66			
	Control	50.36±1.11	50.51±1.93	6.41±-0.15			

(p<.05).

ANOVA test in measuring the endurance of the ankle muscles using the difference (Δ) of the pre-test and post-test scores did not show a significant difference between the groups (Table 4). (p>.05).

Table 4. Results on ankle endurance

Variable	Group	Pre test M± SD	Post test M± SD	Difference (Δ) Pre-test and post-test	Df	F	*P value between-group
Endurance (s)	Plyometric	58.09±1.52	63.61±3.25	2.14±5.24	4	1.08	0.37
	Balance	47.14±3.02	49.49±1.19	3.54±2.08			
	PNF	51.26±2.56	52.61±2.88	3.14±1.18			
	Combination	53.25±1.12	59.46±2.61	2.47±6.38			
	Control	50.37±0.95	50.64±1.96	2.19±0.29			

(p<.05).

ANOVA test using the difference (Δ) of range of motion of the pre-test and post-test scores showed a significant difference between the groups (Table No. 5) to comparison of Tukey test of the two groups showed the significance of the exercises in the combination-plyometric, combination-balance, PNF-balance, PNF-plyometric, control-PNF and combination-control groups (Table 6). (p<.05).

Table 5. Results on ankle range of motion

Variable	Group	Pre test M± SD	Post test M± SD	Difference (Δ) pre-test and Post-test	Df	F	*P value between-group

Rang of motion (d)	Plyometric	68.41±1.72	96.41±2.21	1.48±1.00	4	5.08	0.001*
	Balance	70.11±2.65	70.15±1.45	3.49±0.05			
	PNF	59.96±3.14	63.36±2.31	5.50±3.40			
	Combination	62.21±2.24	67.34±1.64	1.65±5.13			
	Control	59.84±2.02	61.51±1.77	3.66±1.67			

(p<.05).

Table 6. Results of Tukey's range test on range of motion

Group	P-value between group	Group	*P value between group
Control- Plyometric	.618	Combination -Balance	.006*
Control- Balance	.118	Combination – PNF	.095
Control- PNF	.000*	Combination – Plyometric	*.008
Control- Combination	.001*	Plyometric- PNF	*.001
Balance – PNF	.003*	Plyometric-Balance	.662

(p<.05).

ANOVA test in explosive power measurement using the difference (Δ) of the pre-test and post-test scores did not show a significant difference between groups (Table 7). (p> ٠.05).

Table 7. Results on explosive power

Variable	Group	Pre test M± SD	Post test M± SD	Difference (Δ) Pre-test and post-test	Df	F	*P value between-group
Explosive power (cm)	plyometric	44.61±1.65	45.34±2.22	4.41±0.73	4	1.86	0.13
	Balance	49.31±2.11	49.66±1.84	5.58±0.35			
	PNF	48.84±3.12	51.01±2.02	3.56±2.16			
	Combination	42.62±1.95	45.46±1.95	2.75±2.84			
	Control	41.37±1.84	41.61±1.66	1.98±0.23			

(p<.05).

According to Table 8, the ranking of the total points of groups during the 8-week training period and six months after showed the combination group with 18 points (the lowest point) ranked first followed by the balance group with 26 points ranked second. Plyometrics ranked third with 45 points, PNF group ranked fourth with 55 points, and control group ranked fifth with 58 points in terms of the prevention of ankle injury within six months after the training period.

Table 8. Results on damage after training period

Group	Injury during Exercise (member)	Injury after Exercise (member)	Total of Injured Member	Average point of Severity (1-15)	Average of Time Recuperation (1-15)	Average point of Severity Re-injury (1-15)	Average Point of Pain During Exercise (1-15)	Average Point of Pain After Exercise period (1-15)	Total	Ranking in Injury Prevention
Plyometric	0	5	5	9	9	8	4	15	45	3
Balance	0	5	5	5	5	6	4	6	26	2
PNF	0	6	6	10	10	7	2	26	55	4
Combination	0	3	3	3	3	3	6	0	18	1
Control	0	5	5	12	12	6	5	25	58	5

DISCUSSION

The purpose of this study was to comparatively plyometric, balance, PNF and combination training on the functional factors of strength in dorsiflexion and plantar flexion, endurance, range of motion and explosive power of basketball players aged 16 to 18 years for the prevention of injuries of these athletes.

The results of the present study showed that plyometric exercises improved ankle muscle endurance and increased strength only in ankle dorsiflexion, while it had no effect on increasing strength in plantarflexion. The studies of Lee HM et al. (2020) [21], Huang PY et al. (2021) [22], Kotsifaki et al. (2021) [23], are in agreement with this study. Therefore, the main goal of plyometric exercises is to increase the excitability of the nervous system in order to improve the reaction of the neuromuscular system, which is probably the reason for increased muscle strength and endurance [23]. Plyometric exercises are among the important exercises in jumping sports, especially basketball. Also, one of the most common injuries in basketball occurs in the landing position and in dorsiflexion; therefore, it can be argued that strengthening the dorsiflexor muscles can be one of the preventive factors for ankle injury in this sport [24]. The results of this study also showed the third rank of injury prevention for plyometric exercises compared to other studied training methods.

Our findings have shown that PNF exercises increase the power and range of motion of young basketball players aged 16 to 18 years. The studies of Kruse A et al. (2022) showed an increase in power and range of motion, and, Lim W et al. (2024) showed that PNF exercises increased strength and power and did not have a significant effect on the range of motion, which is inconsistent with our results. PNF exercises include exercises to stimulate neurons and increase range of motion, and since basketball is a jumping sport and most ankle injuries are caused by lack of strength during jumping, increasing strength is one of the important factors in preventing injuries [25,26].
According to the results of the current study, the training method based on balance exercises ranked second with respect to the amount of injury prevention that is in agreement with the studies of Al Attar WSA et al. (2022), Baltich J et al. (2014), which showed that balance exercises had a significant effect on the prevention of ankle injuries, confirming the necessity of balance exercises as a supplement to the main exercises [27,28].
In the study of Doherty C et al. (2017), the combination of balance exercises and PNF improved the electrical activity of the ankle muscles and strength in ankle dorsiflexion and plantar flexion in basketball players, and has observed that combination exercises (balance and PNF) in athletes without a history of ankle injury improved the sensation of foot sensors and the amount of pressure applied, but it had no effect on increasing their strength and range of motion. Besides that, Padua E et al. (2019) found that the combination of plyometric and balance exercises increased strength and balance in basketball players, but it did not have a significant effect on their range of motion. In addition observed that the combination of plyometric and balance exercises improved dorsiflexion and plantarflexion strength, but in athletes without a history of ankle injury, did not affect the range of motion, and therefore a series of exercises increases in importance to improve and increase performance factors in order to prevent ankle injury [29,30].
As well, Ruiz-Sánchez FJ (2022) reported an athlete who suffered an ankle injury leading to missing seven training sessions or matches per injury, and the more important issue that should be taken into account is the recurrence of this injury. The recurrence rate of ankle ligament injury in athletes which affects efficiency functional tests will play a substantial role in preventing injury [31].
This study and similar research have revealed that plyometric exercises increase the strength and endurance of ankle muscles and PNF exercises increase the range of motion and ankle power and combination exercises (plyometric and balance), (plyometric and PNF) and (balance and PNF)] separately improve some physical performance factors, but they cannot improve some other factors, but in basketball players, improving and promoting all the performance factors together is essential to prevent and reduce ankle injuries [32] as in this study, it was shown that the combination of plyometric, balance and PNF exercises increased performance factors: strength, flexibility, endurance and power, and according to the (IdFAI_Ar) injury prevention questionnaire, these parameters were investigated during a period of two months of training and six months after the training in athletes. In the comparison between groups, it was shown that combination exercises had the lowest amount of damage and it can be therefore argued that combination exercises (plyometric and balance and PNF) can improve the functional factors.

CONCLUSION

Because of that basketball sport is on brink of high rate of injury therefore ankle twisting and its side effects are very common between young basketball players the necessary of protocol training

for reducing or even eliminating this rate of injury is absolutely important in result of this study, combination exercises can be used as injury prevention exercises in basketball players or even other sports with a high probability of ankle disorders.

Author Contributions: Banafsheh Mohammadi has done the initial idea of reading and the article has written by Banafsheh Mohammadi and Nayeb Ahmadpour. the laboratory work has done by Nayeb Ahmadpour and Mohammad Rabiei.

Funding: This research received no external funding.

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

Data Availability Statement: Data will be available at request.

Acknowledgments: The authors are thankful to all the participants and their families for their participation in this study.

REFERENCES

1. Shahvardi M., Kohestani Urdumohalleh M. The effect of a course of plyometric exercises on the functional symmetry of the lower limbs of soccer players with a history of lateral ankle sprain. Paramedical and Rehabilitation Sciences Quarterly, 2018; 3 (8): 15-24.
2. Shumway CA, Woollacott MH. motor control theory and practical applications. 2edition. us:aA wolters Kluwer company. 2001;58(6):614.
3. Freeman S, Karpowicz A, Gray J, McGill S. Quantifying muscle patterns and spine load during various forms of the push-up. Med Sci Sports Exerc. 1965 Mar;38(3):570-7
4. Stojanović E, Terrence Scanlan A, Radovanović D, Jakovljević V, Faude O. A multicomponent neuromuscular warm-up program reduces lower-extremity injuries in trained basketball players: a cluster randomized controlled trial. Phys Sportsmed. 2023 Oct;51(5):463-471
5. Witchalls J, Blanch P, Waddington G, Adams R. Intrinsic functional deficits associated with increased risk of ankle injuries: a systematic review with meta-analysis. British journal of sports medicine. 2012;46(7): 515-523.
6. Refshauge KM, Kilbreath SL, Raymond J. The effect of recurrent ankle inversion sprain and taping on proprioception at the ankle. Medicine and science in sports and exercise. 2000; 32(1):10-15.
7. Chandler PT, Greig M, Comfort P, McMahon JJ. Variability of Plyometric and Ballistic Exercise Technique Maintains Jump Performance. J Strength Cond Res. 2018 Jun;32(6):1571-1582.
8. Leetun DT, Ireland ML, Willson JD, Ballantyne BT, Davis IM. Core stability measures as risk factors for lower extremity injury in athletes. Medicine & Science in Sports & Exercise. 2004; 36(6):926-934.
9. Hall EA, Chomistek AK, Kingma JJ, Docherty CL. Balance- and Strength-Training Protocols to Improve Chronic Ankle Instability Deficits, Part I: Assessing Clinical Outcome Measures. J Athl Train. 2018 Jun;53(6):568-577.
10. Han J, Anson J, Waddington G, Adams R, Liu Y. The Role of Ankle Proprioception for Balance Control in relation to Sports Performance and Injury. Biomed Res Int. 2015;842804.
11. Alahmari KA, Silvian P, Ahmad I, Reddy RS, Tedla JS, Kakaraparthi VN, Rengaramanujam K. Effectiveness of Low-Frequency Stimulation in Proprioceptive Neuromuscular Facilitation Techniques for Post Ankle Sprain Balance and Proprioception in Adults: A Randomized Controlled Trial. Biomed Res Int. 2020 Sep 23;2020:9012930
12. Lazarou L, Kofotolis N, Pafis G, Kellis E. Effects of two proprioceptive training programs on ankle range of motion, pain, functional and balance performance in individuals with ankle sprain. J Back Musculoskelet Rehabil. 2018;31(3):437-446.
13. Ruiz-Sánchez FJ, Ruiz-Muñoz M, Martín-Martín J, Coheña-Jimenez M, Perez-Belloso AJ, Pilar Romero-Galisteo R, Gónzalez-Sánchez M. Management and treatment of ankle sprain according to clinical practice guidelines: A PRISMA systematic review. Medicine (Baltimore). 2022 Oct 21;101(42):e31087

14. Momeni S, Barati A, Lataftkar M, Ashraf Jamshidi A, Huanlu F. The effect of plyometric exercises on the performance and the amount of feedforward activity of the leg muscles of active women with functional instability of the ankle in single leg landing. Journal of Ilam University of Medical Sciences, 2016; 25(2): 54-42.
15. Refshauge KM, Kilbreath SL, Raymond J. The effect of recurrent ankle inversion sprain and taping on proprioception at the ankle. Medicine and science in sports and exercise. 2000; 32(1):10-15.
16. Eechaute C, Vaes P, Van Aerschot L, Asman S, Duquet W. The clinimetric qualities of patient-assessed instruments for measuring chronic ankle instability: A systematic review. BMC Musculoskeletal Disorders. 2007; 8:610.1186.1471-2474-8-6.
17. Heather Miller A, Louise Fawcett B, Alison R. Original Research Does gender and ankle injury history affect weightbearing dorsiflexion in elite artistic gymnasts? Physical Therapy in Sport. 2012; 32(1):10-15.
18. Dehghan M. Back foot influence on dorsiflexion using three different positions of the weight. bearing lunge test Physical Therapy in Sport, 2020; 47: 1-6.
19.Considine, W.J. Sullivan, W.J. "Relationship of selected tests of leg strength and leg power on college men". J. Research Quarterly. 1973; 44:404-416.
20. Aya A.Khalil, carrie L.docherti. physical theraphy in sport. validity and reliability of the identification of functional ankle instability questionnaire in college _ aged population. 2021; 47: 1-6.
21. Lee HM, Oh S, Kwon JW. Effect of Plyometric versus Ankle Stability Exercises on Lower Limb Biomechanics in Taekwondo Demonstration Athletes with Functional Ankle Instability. Int J Environ Res Public Health. 2020;22;17(10):3665
22. Huang PY, Jankaew A, Lin CF. Effects of Plyometric and Balance Training on Neuromuscular Control of Recreational Athletes with Functional Ankle Instability: A Randomized Controlled Laboratory Study. Int J Environ Res Public Health. 2021;15;18(10):5269.
23. Kotsifaki A, Korakakis V, Graham-Smith P, Sideris V, Whiteley R. Vertical and Horizontal Hop Performance: Contributions of the Hip, Knee, and Ankle. Sports Health. 2021;13(2):128-135
24.Physical Therapy After an Ankle Sprain: Using the Evidence to Guide Physical Therapist Practice. J Orthop Sports Phys Ther. 2021 Apr;51(4):159-160.
25. Kruse A, Habersack A, Jaspers RT, Schrapf N, Weide G, Svehlik M, Tilp M. Acute Effects of Static and Proprioceptive Neuromuscular Facilitation Stretching of the Plantar Flexors on Ankle Range of Motion and Muscle-Tendon Behavior in Children with Spastic Cerebral Palsy-A Randomized Clinical Trial. Int J Environ Res Public Health. 2022 Sep 15;19(18):11599.
26. Lim W. Effect of PNF stretching performed in the AKE position on hip, knee, and ankle flexibility. J Back Musculoskelet Rehabil. 2024;37(2):389-394
27. Al Attar WSA, Khaledi EH, Bakhsh JM, Faude O, Ghulam H, Sanders RH. Injury prevention programs that include balance training exercises reduce ankle injury rates among soccer players: a systematic review. J Physiother. 2022 Jul;68(3):165-173.
28. Baltich J, Emery CA, Stefanyshyn D, Nigg BM. The effects of isolated ankle strengthening and functional balance training on strength, running mechanics, postural control and injury prevention in novice runners: design of a randomized controlled trial. BMC Musculoskelet Disord. 2014 Dec 4;15:407.
29. Doherty C, Bleakley C, Delahunt E, Holden S. Treatment and prevention of acute and recurrent ankle sprain: an overview of systematic reviews with meta-analysis. Br J Sports Med. 2017 Jan;51(2):113-125.
30. Padua E, D'Amico AG, Alashram A, Campoli F, Romagnoli C, Lombardo M, Quarantelli M, Di Pinti E, Tonanzi C, Annino G. Effectiveness of Warm-Up Routine on the Ankle Injuries Prevention in Young Female Basketball Players: A Randomized Controlled Trial. Medicina (Kaunas). 2019 Oct 16;55(10):690.
31. Ruiz-Sánchez FJ, Ruiz-Muñoz M, Martín-Martín J, Coheña-Jimenez M, Perez-Belloso AJ, Pilar Romero-Galisteo R, Gónzalez-Sánchez M. Management and treatment of ankle sprain according to clinical practice guidelines: A PRISMA systematic review. Medicine (Baltimore). 2022 Oct 21;101(42):e31087.
32. Kofotolis N, and Kellis E. Ankle sprain injuries: a 2-year prospective cohort study in female Greek professional basketball players. J Athl Train. 2007; 42: 388-394.

تاثیر چهارنوع تمرین: پلایومتریک، تعادلی، پی ان اف و ترکیبی بر عملکرد جسمانی و پیشگیری از آسیب مچ پا در بازیکنان بسکتبال: کارآزمایی بالینی

بنفشه محمدی[۲] ، نایب احمدپور [۳]، محمد ربیعی[۴]

۱.گروه تربیت بدنی و علوم ورزشی،دانشکده ادبیات و علوم انسانی، دانشگاه شهرکرد،شهرکرد، ایران
۲.گروه تربیت بدنی و علوم ورزشی، دانشکده ادبیات و علوم انسانی، دانشگاه شهرکرد،شهرکرد، ایران
۳.گروه تربیت بدنی و علوم ورزشی، دانشکده ادبیات و علوم انسانی، دانشگاه شهرکرد،شهرکرد، ایران

چکیده:

با توجه به ماهیت بسکتبال تقریباً ۹۲ درصد از آسیب ها در این ورزش تشخیص داده شده است که بیشتر این آسیب ها در اندام تحتانی به ویژه در مچ پا گزارش شده است. هدف از این پژوهش بررسی تأثیر تمرینات پلایومتریک، تعادل، پی ان اف و ترکیبی بر عملکرد بدنی و پیشگیری از آسیب دیدگی مچ پا در بازیکنان جوان بسکتبال بود. این پژوهش یک کارآزمایی بالینی با پیش آزمون و پس آزمون بر روی ۷۵ بسکتبالیست جوان ۱۶ تا ۱۸ ساله در ۵ گروه ۱۵ نفره بود. گروه های تمرینی شامل پلایومتریک، تعادل، پی ان اف و ترکیبی (پلایومتریک و تعادل و پی ان اف) و گروهی که بدون تمرین اضافی بسکتبال بازی می کردند به عنوان کنترل بود. عملکرد بدنی ورزشکاران با اندازه گیری قدرت، استقامت، توان و دامنه حرکت به ترتیب با استفاده از دینامومتر، تخته شیب، تخته پرش سارجنت و الکتروگونیامتر قبل و بعد از دوره تمرین بررسی شد و تعداد آسیب دیدگی مچ پا با استفاده از پرسشنامه اندازه گیری شد. استفاده از پرسشنامه با روایی معقول در طول دوره آموزشی و تا شش ماه پس از دوره آموزشی مورد بررسی قرار گرفت. نتایج، افزایش قدرت دورسی فلکشن را در گروه پلایومتریک و ترکیبی نشان داد، اما افزایش قدرت پلنتارفلکشن فقط در گروه ترکیبی نشان داده شد، بهبود استقامت مچ پا در گروه پلایومتریک و ترکیبی نشان داده شد، بهبود دامنه حرکتی در گروه ترکیبی نشان داده شد. قدرت انفجاری (توان) در گروه های پی ان اف و ترکیبی افزایش یافت. در بررسی پیشگیری از آسیب، تمرینات گروهی ترکیبی، تعادلی، پلایومتریک، پی ان اف و کنترل به ترتیب رتبه های اول تا پنجم را به خود اختصاص دادند. یکی از علل مهم آسیب دیدگی مچ پا در بین بازیکنان بسکتبال، عملکرد ناکافی عضلات مچ پا است. بر اساس نتایج پژوهش، گروه تمرینات ترکیبی نسبت به سایر تمرینات تاثیر بیشتری بر عملکرد بدنی و پیشگیری از آسیب بازیکنان بسکتبالیست جوان داشته و می‌تواند به عنوان تمرین مکمل با تمرینات اصلی در برنامه تمرینی ورزشکاران قرار گیرد.

کلمات کلیدی: بسکتبال، تمرینات پلایومتریک، تمرینات تعادل، تمرینات پی ان اف