

# Effect of Fastened Ankle Multidirectional Jumping Exercise Program on Jumping Performance among Athletes with Chronic Ankle Instability: A Randomised Controlled Trial

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## ABSTRACT

**Introduction:** Chronic ankle instability leads to alterations of ankle joint function, especially during jumping and running leading to diminished athletic performance. Multidirectional jumping exercise program with fastened ankle are required to be explored to overcome the challenges faced by the clinicians for management of ankle injuries, as well as, early return of athletes to sports.

**Aim:** To find out the effect of fastened ankle multidirectional jumping exercise program on jumping performance among athletes with chronic ankle instability.

**Materials and Methods:** This single-blinded randomised controlled trial was conducted at Amity Institute of Physiotherapy, Amity University, Noida, Uttar Pradesh, India in June 2022, and included 30 athletes with  $\geq 6$  months of Grade I and II ankle sprain, with instability and history of two or more episodes of injury. All subjects were distributed into three groups of 10 each. Pain and ankle disability were assessed using Numerical Pain Rating Scale (NPRS), vertical jump test and Foot and Ankle Disability Index tool (FADI-sports module). Therefore, recorded at baseline, 3<sup>rd</sup> week, and 5<sup>th</sup> week of intervention. Group 1

received ankle active range of motion exercises, while Group 2 received multidirectional jumping exercises, and Group 3 received multidirectional jumping exercise program with fastened ankle. Before exercise the involved ankle was taped with rigid tape. One-way Analysis of Variance (ANOVA) was used for between group analysis and ANOVA using repeated measure were used for within group analysis.

**Results:** There was improvement in experimental group (group 2 and 3) from baseline to 5<sup>th</sup> week. Group 3 showed significant improvement in pain (NPRS) with mean difference of 5.4 from baseline to 5<sup>th</sup> week, Vertical jump height (vertical jump test) with mean difference of 24.7 from baseline to 5<sup>th</sup> week, ankle disability (FADI-sports module) with mean difference of 42.80 from baseline to 5<sup>th</sup> week with  $p < 0.001$ . whereas group 2 showed improvement in pain with mean difference of 5.2 from baseline to 5<sup>th</sup> week, vertical jump height with mean difference of 18.5 and ankle disability with mean difference of 44.9 from baseline to 5<sup>th</sup> week with  $p < 0.001$ .

**Conclusion:** The study concluded that, five weeks of fastened ankle multidirectional exercise program improved the jumping performance, among athletes with chronic ankle instability.

**Keywords:** Ankle disability, Ankle sprain, Athletic injury

## INTRODUCTION

Globally, 73.5% of athletes reported chronic ankle instability had history of two or more than two lateral ankle sprains and 25%-40% of athletes who suffered from ankle sprain have the highest chance to have ankle instability [1]. Approximately, 2 million acute ankle sprains occur annually [2] chronic ankle instability has high prevalence in sports like soccer (61%), basketball (65%), volleyball (46%), netball (46%), baseball (34%), badminton, tennis, sprinting, golf, wrestling (10-20%) [3]. A survey on elite, competitive and recreational athletes showed 75.5% of participants reported chronic ankle instability had atleast two sprains of same ankle with a residual symptom after initial injury. Approximately, 20% of adults from general population with a history of lateral ankle sprain reports chronic ankle instability [4].

In India, 73% of athletic population experience chronic ankle instability and among them 59% of them reported history of previous ankle sprains. The previous studies have stated that the impairment-based rehabilitation for athletes with plyometric training improves neuromuscular control through the facilitation of neurological receptors, enhance functional stability of joint and reduce the incidence of ankle injuries [5-8].

Chronic ankle instability has been found in athletes involved in jumping activities [9]. Fastened ankle multidirectional jumping exercise program are designed to enhance jumping performance as vertical loading of musculotendinous unit stores greater elastic

energy during the movement [10]. There is a dearth of literature quoting the effect of multidirectional jumping exercise program with fastened ankle on chronic ankle instability.

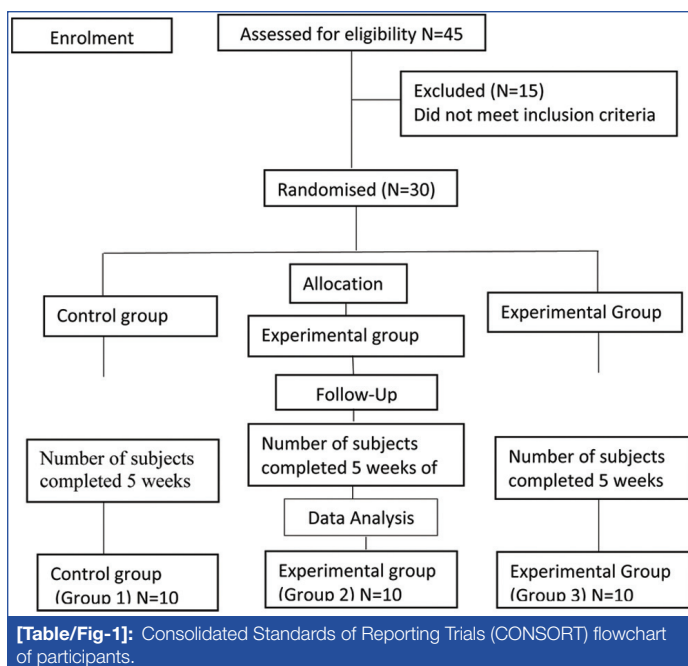
The objective of the study was to investigate the effect of fastened ankle multidirectional jumping exercise program on jumping performance among athletes with chronic ankle instability. The primary outcome measures were changes in NPRS, whereas the secondary outcome measures included the scores of vertical jump test (vertical jump height) and FADI-sports module (ankle disability).

## MATERIALS AND METHODS

The single-blinded randomised controlled trial was conducted at Amity Institute of Physiotherapy, Amity University, Noida, Uttar Pradesh, India, in June 2022. The study was approved by NTCC Ethics Committee of Amity Institute of Physiotherapy, Amity University, Noida, Uttar Pradesh, India (NTCC/MPT-Sports Med/21-22/Nov2021/04) and has been registered in Clinical Trial Registry of India (CTRI/2022/01/039600).

A total of 45 subjects (age 16-25 years) were recruited and screened for eligibility. Out of those, 15 subjects were excluded as they did not meet the inclusion criteria, leaving a total sample size of 30 subjects [Table/Fig-1].

**Sample size calculation:** Sample size was calculated using G\*power 3.1.9.7 program (Heinrich-Heine-Universität Dusseldorf, Germany), a



statistical power analysis program. The sample size was calculated using clinical trial data. The calculated effect size is 0.80 (large effect size). To achieve 0.95 statistical power with an alpha level of 0.05 for a study, at least 30 subjects were required. Informed consents were obtained from all subjects prior to study.

**Inclusion criteria:** Age between 16 and 25 years, both male and female, history of more than one lateral ankle sprain, severity of ankle sprain-grade I and II.

**Exclusion criteria:** History of any other musculoskeletal injuries (muscle and ligament injuries) within last six months. Recent surgery of spine and lower extremity, low back pain, history of neurological condition that can affect balance.

Subject's age, gender, height, weight was recorded. Assessment of anterior drawer test and talar tilt tests was done in the study. After the baseline assessment, 30 subjects were randomised into Control Group (Group 1), Experimental Group (Group 2, 3) by sequentially numbered, sealed, opaque envelope method.

The grades of ankle sprain were classified based on clinical severity: grade I (mild), grade II (moderate), and grade III (severe). A grade I injury involves little swelling and tenderness, minimal or no functional loss, and no mechanical joint instability. A grade II injury has moderate pain, swelling, and tenderness over the involved structures; some joint motion is lost, and joint instability is mild to moderate. A grade III injury is a complete ligament rupture with marked swelling, haemorrhage, and tenderness; function is lost, and joint motion and instability are markedly abnormal [11].

## Outcome Measures

### Primary outcome measure:

1. Pain: The NPRS is a simple, common, and often used scale. In this scale, patients are asked to encircle the number between 0 and 10 that denotes intensity of pain. Where, 0 represents 'no pain at all' and the higher the score represents 'the worst pain ever possible'.

### Secondary outcome measure:

1. Vertical jump height: The athlete was asked to stand wall side and try to reach up with the arm that is closer to wall. By maintaining complete foot contact with the ground, the point at which the fingertip touched was marked and recorded. The athlete was then asked to stand at some distance from wall side and jump vertically by using whole lower body power as high as they can. Score was the difference of distance between both heights (Standing reach height and the jump height). Among three trials, the best score was recorded. The reliability is excellent ranges from 0.97 to 0.99 [12].

2. Ankle disability: The FADI-sports module is a self-reporting tool to evaluate function of ankle joint and assess tasks essential to sports. The FADI-sports module has eight items. Every item in this scale scores from 0 (unable to do) to 4 (no difficulty at all). The FADI-sports score has 32 points. The scoring of FADI-sports module were documented individually in percentage. The FADI-sports module is reliable {Intraclass Correlation Coefficient (ICC)=0.84} in determining the function limitations in chronic ankle instability patients [13].

## Study Procedure

After the pretest assessments were completed, the subjects were assigned to intervention groups. The exercise programs were administered four days per week for consecutive five weeks.

**Control group (Group 1):** During each session, cryotherapy was applied on ankle joint with temperature of 15°C for 10 minutes. The subjects performed ankle active range of motion exercises (plantarflexion, dorsiflexion, inversion, eversion, and combination of all) [14] with two sets each of 10 repetitions by application of rigid tape on affected ankle joint. Duration of each session was 30 minutes per day.

**Experimental group: Group 2 (multidirectional jumping exercise program):** During each session of intervention, cryotherapy was applied on lateral aspect of ankle with temperature of 15°C for 10 minutes followed by multidirectional exercise program (forward jump, backward jump, forward zig-zag jump, lateral jump) with two sets of 10 repetitions in each direction on agility ladder from 1<sup>st</sup> to 3<sup>rd</sup> week, then on hurdles from 4<sup>th</sup> to 5<sup>th</sup> week by application of rigid tape on affected ankle joint. The subjects were asked to perform jump, in which the foot should be fully planted on floor during landing. Duration of each session was 30 minutes per day.

**Group 3 (fastened ankle multidirectional jumping exercise program):** During each session of intervention, cryotherapy was applied on lateral aspect of ankle with temperature of 15°C for 10 minutes followed by multidirectional exercise program (forward jump, backward jump, forward zig-zag jump, lateral jump) with two sets of 10 repetitions in each direction on agility ladder from 1<sup>st</sup> to 3<sup>rd</sup> week, then on hurdles from 4<sup>th</sup> to 5<sup>th</sup> week by application of rigid tape on affected ankle joint with fastened bilateral ankles. The subjects were asked to perform jump in which the foot should be fully planted on floor during landing. Duration of each session was 30 minutes per day.

Assessments were repeated at the 3<sup>rd</sup> and 5<sup>th</sup> week of postintervention.

## STATISTICAL ANALYSIS

The Statistical Package for Social Science (SPSS) 28.0 software version (SPSS inc., IBM Corp, NY) was used for data analysis. Standard statistical methods were used for the calculation of means and standard deviation of variables (NPRS, vertical jump test, FADI-sports module). Significance was set at  $p \leq 0.05$ . One-way ANOVA was used for between groups analysis and repeated measures ANOVA was used for within group analysis with respect to effect of time (pretest and post-test readings).

## RESULTS

Descriptive characteristics of age, height and weight were calculated using excel sheet [Table/Fig-2].

Intragroup comparison showed statistically significant improvement between group 2 and 3 with mean value from baseline reading to 5<sup>th</sup> week of intervention on pain (NPRS) score [Table/Fig-3], vertical jump height (vertical jump test) score [Table/Fig-4], and ankle disability (FADI-sports module) score [Table/Fig-5].

Intergroup comparison in NPRS, vertical jump test and FADI-sports score showed statistically significant between control (Group 1) and experimental (Group 2 and 3) [Table/Fig-6].

Variables	Age (years)	Weight (kg)	Height (cm)
Group 1	19.3±2.62	70.1±13.96	168.8±2.25
Group 2	22.9±11.62	52.0±7.51	162.6±11.20
Group 3	21.1±2.99	63.7±11.29	173.3±10.58
p-value	0.14	0.14	0.06

**[Table/Fig-2]:** Descriptive characteristics of all subjects.  
p-value <0.05 is considered significant

Time	Mean±SD			F-value	p-value
	Group 1	Group 2	Group 3		
Pretest	5.40±1.07	5.90±1.37	6.30±0.67	2,27=1.748	0.193
Post-test 3 <sup>rd</sup> week	3.50±1.90	3.10±1.28	3.80±0.63	2,27=6.073	0.007
Post-test 5 <sup>th</sup> week	1.00±1.05	0.70±0.48	0.90±0.73	2,27=50.636	<0.001

**[Table/Fig-3]:** Intragroup comparison of Numerical Pain Rating Scale (NPRS).  
NPRS: Numerical pain rating scale; p-value <0.05 is considered significant

Time	Mean±SD			F-value	p-value
	Group 1	Group 2	Group 3		
Pretest	30.00±5.59	33.50±5.74	32.20±6.51	2,27=0.880	0.426
Post-test 3 <sup>rd</sup> week	30.10±5.82	42.70±7.499	44.90±6.88	2,27=13.910	<0.001
Post-test 5 <sup>th</sup> week	30.20±5.53	52.10±7.41	56.90±5.44	2,27=52.727	<0.001

**[Table/Fig-4]:** Intragroup comparison of vertical jump test score.  
p-value <0.05 is considered significant

Time	Mean±SD			F-value	p-value
	Group 1	Group 2	Group 3		
Pretest	46.90±10.34	40.30±2.98	44.20±8.92	2,27=1.688	0.204
Post-test 3 <sup>rd</sup> week	46.90±10.34	67.10±3.17	67.20±5.13	2,27=28.579	<0.001
Post-test 5 <sup>th</sup> week	46.80±10.32	85.20±4.05	87.00±3.46	2,27=114.568	<0.001

**[Table/Fig-5]:** Intragroup comparison of FADI-sports module.  
p-value <0.05 is considered significant

Groups	Time	Group 1		Group 2		Group 3	
		Mean difference	p-value	Mean difference	p-value	Mean difference	p-value
NPRS	Baseline-5 <sup>th</sup> week	4.40	0.008	5.40	<0.001	5.20	<0.001
Vertical jump test	Baseline-5 <sup>th</sup> week	0.20	0.573	18.60	<0.001	24.70	<0.001
FADI-sports score	Baseline-5 <sup>th</sup> week	0.10	0.343	44.90	<0.001	42.80	<0.001

**[Table/Fig-6]:** Intergroup differences in NPRS, vertical jump test and FADI-sports score.  
p-value <0.05 is considered significant

## DISCUSSION

The main objective of the present study was to investigate the effect of fastened ankle multidirectional exercise program on jumping performance among athletes with chronic ankle instability. The results showed that the intervention has improved the pain, vertical jump height and ankle disability. The intervention might have improved the stretch-shortening cycle of muscle-tendon units that optimises the muscle-tendon behaviour of agonist muscle, associated with alteration in neuromuscular activity during stretch-shortening exercise and an increase in tendon stiffness. Furthermore, a decrease in the neuromuscular activity of the antagonists during the braking phase appears to play an important role in this improvement as the mechanism of joint stiffness increases due to greater force of agonists and less force in antagonists during braking phase as well as an increase in tendon stiffness [15].

The NPRS showed significant improvement in group 3 pain intensity from pretest to post-test 3<sup>rd</sup> week and 5<sup>th</sup> week readings [Table/Fig-3]. The cryotherapy may reduce pain intensity by reducing the nerve transmission velocity (motor and sensory) in pain fibres when the temperature of skin falls till 15°C, that leads to increase in pain threshold and tolerance [16]. Thus, may provide an analgesic effect thereby minimising magnitude of inflammatory response by decreasing proinflammatory cytokine TNF- $\alpha$  and increase in anti-inflammatory cytokine IL-10 [17]. Similar studies have been found in the past, on acute ankle sprains and musculoskeletal injuries on elevation of pain threshold include an antinociceptive effect on pain gate system, thereby, reduce nerve conduction, muscle spasm and prevention of oedema in musculoskeletal injuries [18,19].

Vertical jump test showed significant improvement in vertical jump height from pretest readings in group 3 [Table/Fig-4]. This may be due to greater recruitment of motor units, that may increase in activation of leg muscles which may improve the musculotendinous and joint stiffness, thereby reduces the phase of amortisation in the stretch-shortening cycle, and thus improving the jumping performance [20,21]. Similar studies have been done in the past on improving the vertical jump height among soccer players and basketball players to enhance physical fitness in which multidirectional training program enhanced postural control in multiple axes, as improved landing tasks and lower limb muscle strength and recruitment strategy which help an athlete to perform jump efficiently [22,23].

The FADI-sports module showed significant improvement in group 3 [Table/Fig-5]. Athletes with chronic ankle instability noted high-level functional loss in sports module such as running, jumping, and cutting, revealed most of an athlete's felt pain or reduced ability as compared to preinjury level. Enhancement in ankle function has a direct relationship with improvement in other reported deficits [24]. In present study, five weeks of fastened ankle multidirectional jumping exercise program significantly improved pain and vertical jump height. Thus, improving the FADI-sports module score. Similar studies also reported, improvement in patients with chronic ankle instability and functional limitations, who benefitted with rehabilitation programs [24,25].

## Limitation(s)

The study was limited to 16-25 years, duration of treatment regimen of 30 minutes per day and four days per week.

## CONCLUSION(S)

The study concluded that, five weeks of fastened ankle multidirectional jumping exercise program improved the jumping performance among athletes with chronic ankle instability. Future research can be performed on other sports with different age groups, and other population.

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