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Effects of proprioceptive versus conventional exercises on balance and lower extremity functions in individuals with ankle instability in ankle sprain

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Abstract
Background: Sprains constitute 85% of ankle injuries. Despite the high prevalence, these are often regarded as injuries that will resolve on their own and therefore many people do not seek treatment, resulting in functional and/or chronic instability and/or residual ankle instability. A study is needed so recurrence of ankle sprains can be prevented.
Methods: Prospective, comparative study design with convenient sampling. Patients diagnosed with grade 2 ankle sprain were taken. They were assessed using the Star Excursion Balance Test for ankle instability and balance, Lower Extremity Functional Scale for functional mobility, Visual Analog Scale for pain and Modified Oxford Scale for muscle strength. The experimental group (n = 09) received both proprioceptive and conventional exercises. The control group (n = 09) received only conventional exercises. Patients were assessed at the baseline and at the end of 4th week for balance, functional mobility, pain and muscle strength.
Results: Post intervention, balance improved on SEBT score significantly (p = 0.01) more in experimental than in control group. Difference between both the groups was statistically significant (p = 0.02) for LEFS score. Pain reduced significantly (p = 0.02) on VAS score in experimental than in control group. Muscle strength improved significantly (p = 0.00) more in the experimental than in control group.
Conclusion: Proprioceptive exercises along with conventional occupational therapy exercises in ankle sprain are effective in improving balance, lower extremity functions, muscle strength.

Keywords: Ankle sprain, balance, lower extremity functional scale, proprioception, star excursion balance test

Introduction

The human foot complex is an intricate, multi-joint mechanism, which is fundamental for the interaction between the lower limb and ground during locomotion [1]. The ankle/foot complex meet the stability demands of (1) providing a stable base of support for the body in a variety of weight-bearing postures without excessive muscular activity and energy expenditure and (2) acting as a rigid lever for effective push-off during gait [2]. A sprained ankle, also known as a twisted or rolled ankle, is a common injury where sprain occurs on one or more ligaments of the ankle. Sprains constitute 85% of ankle injuries, and most of those are due to lateral inversion mechanism. Risk factors include previous history of ankle sprain, muscle and ligament fatigue,-history of obesity, carrying excess weight and poor athletic conditioning [3]. The previous history of a sprained ankle is the commonest predisposing factor to experiencing an ankle sprain. The development of repetitive ankle sprains and persistent symptoms after injury has been termed chronic ankle instability (CAI). Returning to activity before the ligaments have fully healed may cause them to heal in a stretched position, resulting in less stability at the ankle joint, causing chronic ankle instability (CAI). Impairments of neuromuscular control and stability may both be sequelae from ankle injuries.

The three major contributors to stability of the ankle joints are (1) the congruity of the articular surfaces when the joints are loaded, (2) the static ligamentous restraints, and (3) the musculotendinous units, which allow for dynamic stabilization of the joints [4].

As balance and joint stability mutually depend on sensory input from peripheral receptors, balance can be interpreted as a function of joint stability. If the mechanoreceptors are damaged when an ankle sprain occurs, proprioception will be affected, which results in a reduction in the body's ability to balance. Despite the high prevalence and severity of lifestyle-limiting symptoms that follow the injury, ankle sprains are often regarded as injuries that will resolve on their own and therefore many people who suffer ankle sprains do not seek treatment, resulting in functional and/or chronic instability and/or residual ankle instability [5]. It also results in varying degrees of debilitation including decreased performance, absence from work and adverse psychological effects [5].

Ankle sprains can lead to affected proprioception, ankle instability causing balance issues, affecting functional mobility of the individual. No studies have been conducted to assess the effectiveness of proprioceptive exercises on lower extremity functions and functional mobility in ankle sprain. Hence, the need arose to conduct this study so recurrence of ankle sprains can be prevented by improving functional mobility. The objective was to study the effect of proprioceptive and conventional exercises individually on balance and lower extremity functions in ankle sprain.

Materials & Methods

Prospective, comparative study was designed with convenient sampling method. The study was conducted for the duration of one year. Institutional Ethics Committee permission was taken. Written consent was taken from the patients in the language best understood (Hindi, Marathi, and English).

Patients diagnosed with grade 2 ankle sprain were referred from the orthopedic OPD to the occupational therapy department. Patients between 18-40 years of age, grade 2 ankle sprain, BMI <25 and from both genders were included in the study and patients with bilateral ankle sprain, vestibular/neurological disorder, surgery or trauma to lower extremity surgery/ polytrauma were excluded.

Initially, the calculated sample size was 30 (Control 15, Experimental 15). Due to the pandemic, sample size was reduced to 20 with Institutional Ethics Committee sanction. Therapy protocol was also reduced to four weeks with therapy sessions once a week. The experimental group (n = 09) received both proprioceptive and conventional exercises. The control group (n = 09) received only conventional exercises. Subjects received cryotherapy in the form ice pack for 10 minutes around the ankle joint, before and after the therapy session. Each session lasted up to 45 minutes for both control and experimental group, with adequate rest periods. Patients were assessed at the baseline and at the end of 4th week for balance, functional mobility, pain and muscle strength. Outcome measures included Star Excursion Balance Test (SEBT) for ankle instability and balance, Lower Extremity Functional Scale (LEFS) for functional mobility, Visual Analog Scale (VAS) for pain and Modified Oxford Scale (MOS) for muscle strength.

a) The Star Excursion Balance Test (SEBT) [15] was developed as a reliable measure for dynamic stability. Originally described by Gray as a rehabilitative tool, the SEBT is a series of single-limb squats using the non-stance limb to reach maximally to touch a point along 1 of 8 designated lines on the ground. While standing on a single limb, the participant reaches as far as possible with the reaching limb along each reaching line; lightly touches the line with the most distal portion of the reaching foot without shifting weight to or coming to rest on this foot of the reaching limb; and then returns the reaching limb to the beginning position in the center of the grid, reassuming a bilateral stance. *Formula:* Average distance in each direction (cm)= Reach 1+Reach 2+Reach 3 / 3.
b) The Lower Extremity Functional Scale (LEFS) (16, 17) a questionnaire containing 20 questions about a person's ability to perform everyday tasks. It can be used to evaluate the functional impairment of a patient with a disorder of one or both lower extremities. The columns on the scale are summed to get a total score. The maximum score is 80. Lower the score, greater is the disability and vice versa. Percentage of maximal function = (LEFS score) / 80 x 100.

Table 1: Exercise protocol

Week	Control Group (Conventional Exercise)	Experimental Group (Conventional + Proprioceptive Exercise)
1	Ankle pumps Isometrics Calf stretch Towel slides	Peroneal bridging Single-leg stance on foam Single-leg hops
2	Ankle pumps Isometrics Towel curls Ankle spring board	Step-ups Square hops Jumps (Bilateral legs)
3	Ankle pumps Isometrics Pick-up exercises Heel raise, drop	Thera-band stretch Wobble board or Stability trainer Walk jogs
4	Ankle pumps Isometrics Walk on heels, toes Ankle lifts	Quadrant hops Rope jumps Jump and wall ball Crossover runs

Data Analysis & Results

The data was entered using MS-Excel and analysed using SPSS-16 software. Descriptive analysis for numerical data consists of mean (M) with standard deviation (SD) and the categorical data consists of frequencies and percentages for various parameters.

Table 2: Demographic Data

Characteristics		Control (n = 9)	Experimental (n = 9)
Age (years)		**26.55±7.79**	**26±5.47**
Gender	Male	5 (55%)	4 (44%)
	Female	4 (44%)	5 (55%)
Weight (kg)		51.22±11	53.55±4.87
Height (cm)		158.94±7.01	162.66±14.25
BMI		20.03±2.66	20.31±2.57
Ankle sprain (Rt/Lt)		6/3	4/5

Table 3: Inter-group comparison scores

SEBT								
	Control			Experimental			Inter-Group Comparison	
	Mean	**SD**	**CI**	**Mean**	**SD**	**CI**	**T value**	**P value**
Baseline	60.66	16.99	47.60, 73.71	75.11	18.55	60.85, 89.36	-1.72	0.10
4 Weeks	67.44	15.39	55.61, 79.26	87	12.95	77.05, 96.95	-2.91	0.01*
Difference	6.78	1.6	5.55, 8	11.89	5.6	7.58, 16.19	-1.55	0.13
LEFS								
	Control			**Experimental**			**Inter-Group Comparison**	
	Mean	SD	CI	Mean	SD	CI	T value	P value
Baseline	41.88	14.70	30.58, 53.17	43.55	13.36	33.28, 53.81	-0.25	0.80
4 Weeks	56.66	11.64	47.71, 65.60	67	9.35	59.81, 74.19	-2.07	0.05
Difference	14.78	3.06	12.42, 17.13	23.45	4.01	20.36, 26.53	-2.56	0.02*
VAS								
	Control			**Experimental**			**Inter-Group Comparison**	
	Mean	**SD**	**CI**	**Mean**	**SD**	**CI**	**T value**	**P value**
Baseline	6	1.22	5.06, 6.94	6	1.22	5.06, 6.94	0	1
4 Weeks	3.55	1.13	1.98, 3.77	2.33	1	1.56, 3.09	2.42	0.02*
Difference	2.45	0.09	5.58, 5.71	3.67	0.22	3.50, 3.83	-2.75	0.00*
MOS								
	Control			**Experimental**			**Inter-Group Comparison**	
	Mean	**SD**	**CI**	**Mean**	**SD**	**CI**	**T value**	**P value**
Baseline	3.11	0.33	2.88, 3.55	3.33	0.5	2.94, 3.71	-1.10	0.28
4 Weeks	4.11	0.33	3.94, 4.71	5	0	5, 5	-8	0.00*
Difference	1	0	1, 1	1.67	0.5	1.28, 2.05	-2.82	0.01*

*****p value <0.05 taken as statistically significant.

Table 4: Correlation between Star Excursion Balance Test and Lower Extremity Functional Scale

SEBT	LEFS
N = 18	0.42
Pearson Correlation (R)	
P value	0.07

Correlation between Star Excursion Balance Test and Lower Extremity Functional Scale was done using Pearson Correlation (R) Test. With R= 0.42 at p value 0.07, it showed a weak positive correlation between balance and lower extremity functions.

Discussion

A total of 20 subjects meeting the inclusion criteria and were included. They were assigned to control (n = 10) and the experimental (n=10) group through convenient (lottery) sampling method. Two subjects dropped out of the study. As per table 1, subjects with mean age (26.55±7.79) years for control and (26±5.47) years for experimental were included in this study. Younger adult is more physically active age group, which is more prone to ankle injuries causing ankle instabilities. Whereas in older adults (50 to 90 years), neuromuscular functioning is affected due to normal aging process. This can be supported by Zdenek Svoboda *et al* (2019) in which the correlation was studied for younger and older subjects with muscle strength. It concluded that aging has an effect on the ankle muscle strength and the control of bipedal stance [6]. Obese subjects are more likely to sustain severe ankle or calcaneus fracture and the exercise protocol designed for the study could be more strenuous for them. Hence subjects with mean BMI (20.03±2.66) in control and experimental (20.31±2.57) group were included in this study, seen in table 1. This is supported by Christy King (2013) who stated obese patients are more likely to sustain an ankle fracture, contributing factors may include increased torque on the ankle or low bone mineral density relative to body weight [7]. As per table 3, balance improved on SEBT score significantly (p = 0.01) more in experimental than in control group, post-intervention. Whereas, difference between SEBT scores of control group and experimental group is not statistically significant (p = 0.13). The stability of the ankle joint is paramount when considering regulation of balance. Balance and joint stability mutually depend on sensory input from peripheral receptors. Thus, proprioception plays essential role in regulating balance by way of neuromuscular control. The significant change in balance for experimental group could be due to incorporation of proprioceptive exercises to conventional occupational therapy program. This finding can be supported by A. Ben Moussa Zouita *et al* (2013) in which the effects of proprioceptive exercises on balance in athletes with sprained ankle was studied. It concluded that proprioceptive training exercises can effectively stabilize an unstable ankle for postural and muscular control [8]. Troy Blackburn *et al* (2000) studied the dominance of proprioception on balance and joint stability. It concluded enhancement of proprioceptive mechanisms is effective in promoting joint stability and the reciprocal maintenance of balance [9]. As per table 3, the difference between both the groups was statistically significant (p = 0.02) for LEFS score. Whereas, 4 weeks post-intervention no significant (p = 0.05) change was found between both the groups. Clinically, the findings were significant in experimental than in control group. The ability to mechanically reduce gravitational force on the body while performing functional activities during weight-bearing exercise allows exact control over the amount of stress to the lower extremities. Precise incremental progression of weight-bearing on the lower extremities during exercise provides a smooth and tolerable transition to full weight-bearing activities. Good proprioception is important for promoting dynamic joint and functional stability during standing, walking, running, and in activities of daily living [8]. This is in accordance with study by Rebecca Kern-Steiner *et al* (1999) where the subject was able to return to running and soccer activities after participating in a training program where neuromotor adaptations were facilitated by the use of controlled functional training in weight bearing positions [10]. According to table 3, pain reduced significantly (p = 0.02) on VAS score in experimental than in control group, post-intervention. Also, the difference between both the groups was significant (p = 0.01), post intervention. This could be because our subjects received cryotherapy before and after the therapy session, and they were allowed to use adhesive compression if required, which must have helped in reducing pain. Pain arising from musculoskeletal system is often caused by muscle spasm. Application of ice decreases pain after injury by reducing nerve conduction or spasmodic muscle shortening or have an antinociceptive effect on the gate control mechanism. Thus, it reduces the degree of secondary cell injury, thereby minimising the magnitude of the inflammatory response. Chris Bleakely *et al* (2006) in his study concluded that the application of an intermittent cryotherapy protocol after mild or moderate ankle sprain significantly reduced the level of subjective pain on activity, compared with a standard protocol. Thus, an intermittent application has enhanced the therapeutic effect of ice after acute soft tissue injury, helping in pain relief in the early stages of rehabilitation [11]. J E Hocutt Jr *et al* (1982) compared the use of cryotherapy versus heat therapy to assess recovery from ankle sprain. It concluded cryotherapy is an effective treatment for ankle sprains yielding earlier complete recovery by reducing pain than heat therapy [12]. As per table 3, muscle strength improved significantly (p = 0.00) more in the experimental than in control group. Since proprioception and muscular strength play essential roles in regulating balance through neuromuscular control, usage of proprioceptive along with muscle strengthening exercises helps in reducing ankle instability. This is supported by Troy Blackburn *et al* (2000) which suggested specific rehabilitation protocols involving strength training, proprioceptive training, and a combination of both are effective in improving subjects' ability to perform tasks [9]. Tine Willems *et al* (2002) in his study stated that cause of ankle instability is the combined action of diminished proprioception and ankle muscles' weakness. His findings affirm the importance of proprioception training and strength training of the peroneal muscles in the rehabilitation of ankle injuries. It was concluded that proprioceptive and strengthening exercises effectively stabilize an unstable ankle and break the vicious cycle of recurrent sprains and subsequent loss of proprioception and muscle atrophy [13]. As shown in table 4, there is weakly positive correlation (R = 0.42) between balance and lower extremity functions. This could be because of one's tendency to report ankle instability as "giving way" during normal activity. Kerry M. Demeritt *et al* (2002) reported that ankle instability does not negatively influence actual functional performance [14]. Limitations of the study were small sample size, and subjects with age more than 40 years were not considered in the study.

Conclusion

Study concluded that proprioceptive exercises along with conventional occupational therapy exercises in ankle sprain is effective in improving balance, lower extremity functions, muscle strength. The intervention will help improve balance and lower extremity functions, thus improving work productivity and daily activity performance in patients with ankle instability due to ankle sprain. Also, the knowledge of proprioceptive exercise program in these patients can be used effectively in occupational therapy practice.

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