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Rehabilitation of Acute and Chronic Ankle Sprain for Male Cricketers Through Headway (Isometric, Isotonic and Proprioception) Exercises

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study investigated that Headway (Isometric, Isotonic and Proprioception) exercises are effective for acute & chronic ankle sprain injury, which was observed through experimental research. Ninety-four amateur cricketers of age, 15-35 years (Control Injured, N=48; Headway Rehab Group N=46) with a confirmed acute or chronic ankle sprain, selected from four different cities of Punjab, Pakistan was evaluated through Star Excursion Balance Test (SEBT), Single Leg Balance test (SLB) and subject to a set of progressively increasing exercises on ground known as Headway rehab exercises which consisted of Isometric, Isotonic and proprioception protocols. Another group of the same level of cricketers (N=40) was managed parallel for comparisons. The

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Control Injured and Headway Rehab Group was left with 40 subjects each because during the course of Headway exercise eight and six subjects left the study due to their personal reasons. Comparisons of pre and post-exercise (Control Injured Group) values showed a significant increase ($p<0.001$) in Lateral direction reach and Posteromedial direction ($p<0.05$) while the rest of the six directions showed non-significant results. Headway Rehab Group showed an overall improvement of 5.2% and 7.5% with an increase (cm) of 3.4 and 4.9 for the non-injured and injured leg respectively. However, the range of improvement in percentage for all eight directions (anterior, anterolateral, lateral, posterolateral, posterior, posteromedial, medial, anteromedial) lies between 5.7-7.1(range) and 6.3-9.6 (range) for the non-injured and injured leg respectively. Similarly, the difference between pre and post-exercise difference of two positions of non-injured leg and injured leg (closed and open eyes) in seconds were 2.9, 12.1 and 4.1, 27.7 respectively. However, the improvement percentage of two directions (closed and open eyes) of Headway Rehab Group was 44.9 and 75.3 for non-injured and 12.7 and 51.6 per cent for injured group respectively. It was evaluated through the Single Leg Balance Test and analyzed by paired sample t-test found highly significant ($p<0.001$). The results indicated that Headway exercises improved isometric and isotonic muscular strength, proprioception and stability that ultimately helped to recover, regaining strength and reinstall proprioception. After completing the Headway Rehab plan the subjects were followed for four months to check the recurrence and found recurrence of Control Injured Group and Headway Rehab Group was 17.5% and 12.5% respectively.

Keywords: Ankle sprain; acute; chronic; rehabilitation; proprioception exercises; recurrence.

1. INTRODUCTION

An acute ankle sprain is defined as “A traumatic injury to the overstretching of the ligament of the ankle joint as a result of inversion and eversion or a combined plantar flexion and adduction of the foot” [1]. This commonly affects some initial deficits of function and disability [2,3,4,5]. A chronic ankle sprain is defined as “An old injury that doesn’t heal properly, leading to re-injury of weakened tissues [6]”. Sometimes athletes with injury do not consider it a big deal and do not seek medical attention which may result in prolonged pain and recurrence of ankle sprain [7,8,9,10]. In past, classic techniques have been in use to treat this injury and to check the risk factors, e.g, electronic stimulation, taping, cryotherapy, bracing, mobilization, strength training, proprioception and postural sway methods [11,12,13,14,15,16].

The pre-exercise and post exercise values have been evaluated through Star Excursion Balance Test (SEBT) and Single leg balance test (SLB). The purpose of the tests was to obtain baseline information. SEBT is a simple, efficient, accurate and dynamic assessment during which the subject has to maintain his center of gravity without losing balance and it can differentiate subjects with lower extremity injuries. Therefore, it might be used as a baseline indication of normalization of neuromuscular control after ankle sprain injury. The SLB was a static balance test executed as the subject standing on one leg near a wall (support) and time has been noted in seconds. Both the test were discarded if the subject was unable to maintain his balance [17].

Our present study was conducted on amateur cricketers with confirmed Acute and Chronic ankle sprain selected from four major cities of Punjab (Lahore, Faisalabad, Gujranwala, Sialkot) from December 2016 to December 2018. Headway exercise plan (dorsiflexion, plantar flexion, inversion movement eversion movement and mobilization walking and jogging, standing on one leg with (open and closed eyes)) and evaluated through SEBT and SLB Test. Headway exercise session utilized the principle of progression, overloading and specificity for eight weeks. The exercise session increased at least 10% in every weekly plan [18]. The intensity of the exercises was weekly increased till eight weeks from light to high along with two unloaded weeks (4^{th} and 8^{th}) which took the load off in these weeks.

2. LITERATURE REVIEW

Strength exercises were elaborated as “Application of high force against a heavy resistance”. Functional training is defined as the indolent of muscles or a group of muscles more than simply increases the force-producing capacity, rather it requires physical modification to enhance the coordinated working relationship between the nervous and muscular system. Functional rehabilitation involves controlled

movements in an area of dysfunction, in such a manner that it improves the strength, conditioning and coordination which directly improves the performance of an individual's [19].

Miller and Bird [20] have described that the proximal musculatures are more important than the distal ankle muscles in maintaining body balance (Lee and Jung, 2012). Muscle strength had great importance in rehabilitation, as it helped to rehabilitate the fibers quickly and efficiently as compared with other methods. The scholar observed that neuromuscular and proprioception training should be included to enhance the muscle strength [21]. Some studies have described that peroneal muscle weakness is a considerable factor in ankle sprain [22,23]. After injury, in early rehabilitation isometric exercise must be involved [24], along with continued strengthening which is required initially with isotonic exercises that creates a muscles tension and alteration in muscles size to stimulate the physiological functioning of fibers (Milch, 1996).

Baumhauer et al. [25] and Wilkerson et al [23] had shown that eversion-to-inversion strength ratios are often different in subjects with ankle instability when compared with normal subjects. They also investigated that the inversion eversion strength ratio improved through strength and proprioception training protocols and found the difference between involved and uninvolved ankles study that led to the investigation of reciprocal muscle-group ratios. Docherty et al. [26] worked on ankle strength training and concluded that ankle strength exercises improved strength in subjects with functionally unstable ankles.

Eils and Rosenbaum [27] proposed that multi station proprioception exercise program can be useful for prevention and rehabilitation of chronic ankle sprain. Ashton-Miller et al. [28] proposed that strength and coordination might improve the ankle muscle motor problems while working and observed that the training enhanced with small weight-bearing challenges and balance. Their finding showed the improvement of proprioceptive and prevent injury from light to moderate activity. After achieving the ROM, functional rehabilitation should be started as earlier as possible to regain strength [29,11]. Zoch et al. [30] deduced a lot about the combination of strength, endurance and proprioception training which showed that it had great importance in restoration of the ankle sprain recovery. Willems et al. [31] concluded that combination of strength and proprioception must be included in the rehabilitation of ankle sprain as the ankle patient faced worse condition of evertor and invertor strength muscles along with proprioception. Stasinopoulos [32] worked on the methods of inversion ankle sprains preventions and observed that training methods is more effective and efficient on the ankle sprain injury reductions as compared with other treatments. To avoid re-injury or risk of re-sprain there must be a proper rehabilitation plan that strengthens the local muscles and considered it as an essential for regaining the full range of motion (functionality) by doing ankle strength training [33,34]. Beynnon et al. [35] recommended that functional treatment has better output as it combined with external support to reduce recurrence. Zech et al. [36] demonstrated that strength, endurance and proprioception training had great importance in the restoration of the ankle sprain. They also concluded ankle disc training, isokinetic training and cross over training along with taping had played an important role in regaining the range of motion (ROM). Similarly, other scholars also indicated that a well-planned rehabilitation program of early proprioception and strength will reduce the risk of "Recurrent ankle sprain with functional instability (RAFSI)" [37].

Bleakley et al. [38] investigated that using the gradual progression in exercise training after ankle sprain trauma helps to improve short term functioning as compared with ordinary or standard care. The muscle strength development was the common problem with foot and ankle injuries, depending on the age group and needs a deep evaluation and management through the history of the subject.

Smith et al. [39] concluded that strength was useful for rehabilitation for ankle injuries but it did not improve fore sense of the ankle for improving the for sense proprioceptive training must be included in rehabilitation protocols. The combination of strength and proprioception exercises are more effective interventions than applying strength exercises alone on functional unstable ankle [40]. Another group of scholars Zhang et al. [41] cited, how therapy assisted by robots that effected ankle strength, recovery of muscles, bones and neuromuscular trauma to progressive strength training to recover the ankle sprain injury which lead to improve ankle dorsiflexion motion. The strength training was important for rehabilitation of ankle sprain while

strength had a space to improve an ankle anterior portion of the joint. [39,12,13,15] (Blanchette et al., 2014).

One study was exclusive on postural control measures for those with chronic ankle instability and stability rehabilitation under supervision has shown better results than a home balance program. Balance training during the preseason and in-season led to significant reductions in ankle sprains when performed in a team setting during the regular training or practice session. This method had much better subject compliance as well (90%) when compared to a home-based program which had only 60.3% compliance [42].

A combination of proprioception, muscle strengthening, and balance are effective for patients with functional ankle instability [43,44]. Hall et al. [45] concluded in their study that proprioceptive training with strength protocol was an effective treatment to improve strength individuals with ankle instability. The combo of both protocols was beneficial for regaining strength of ankle.

Doherty et al. [46] and Whitehead (2017) proposed that proprioception training, mobilization and strength training which might help in regaining stability, balance and co-ordination in ankle sprain condition. Return to normal position with minimal risk factor along with harmless approach, while stronger than earlier. The strengthening of ankle muscles with 20 min duration and focusing on enhancing ankle range of motion exercises was proposed by Bleakely et al. (2010). Hung [47] investigated that balance training improved the strength of muscles and ankle specially tendons. Chronic instability was thought to be the result of neural (proprioception, reflexes, muscular reaction time), muscular (strength, power, and endurance) and mechanical mechanisms ligamentous laxity [48]. Progression exercise protocol helps to improve the acute ankle functions treatment under normal observations and care [10]. Sousa et al. [49] studied in unilateral CAI athletes by evaluating them by bilateral proprioceptive training and concluded that proprioception impairment of injured limb might increase the risk of injury if bilateral force was inappropriate.

Long et al. [50] conducted a literature review to explore and observe the ankle sprain prevention and treatment of ankle sprain followed by a suitable and effective rehabilitation program with a functional progression to return to original work activities. Athletes risk factor of ankle injury has been investigated and suggested that the training program should include single leg balance and proprioception to cope with the risk of ankle sprain injury [51]. Hall et al. [52] investigated that combination of strength and balance training is beneficial for improving ankle functional performance, resistance band and PNF strength training was also effective for reduction of ankle sprain recurrence. Rivera et al. (2018) studied on lateral ankle sprain through proprioception and resulted that proprioceptive training was effective to reduce ankle sprain injury and also helpful to decrease the interior reach distance. A combination of neuromuscular and proprioception training with addition to the strength exercises is one of the best treatments among ankle sprain injuries [53]. Alahmari et al. [54] deduced in their study that progressive strengthening and proprioceptive training protocols significantly improves stability, balance and ankle functional performance and also included in the rehabilitation to accelerate recovery and helpful in prevention of chronic ankle sprain.

2.1 Isometric Strength Exercises

The resistance-based exercises that help in strengthening and toning muscles with no change in length of the muscle fibers (The American Heritage® Stedman's Medical Dictionary). Kaminski et al. [55] examined ankle eversion concentric, eccentric and isometric strength and found no difference between subjects with Chronic ankle instability (CAI) and matched-paired controls. The combination of isometric strength exercises along with proprioception showed best results in final rehabilitation assessment [53]. Though, the combination of isokinetic and strength training after surgery proved that rehabilitation through these protocols showed significance after recovery and showed best effects through the components of exercises [56]. A significant work on chronic lateral ankle instability (CLAI) rehabilitation by working on a combination of strength and proprioception helped to recover injury effectively along with postural stability [57].

2.2 Isotonic Strength Exercises

Isotonic comes from the Greek "iso", equal + "tonos", tone = maintaining equal (muscle) tone. Thus, muscle maintained equal tone while shortening in isotonic exercise [58]. Dubin et al.

[18] investigated isotonic strengthening utilizes in final process with eccentric exercises, which places the greatest force on the muscles. Mattacola and Dwyer [29] presented functional treatment protocols to manage ankle ligament injuries, which consisted of various modalities such as flexibility exercises, strength and balancing training, ankle joint proprioception and muscular strength training (isometric and isotonic strength) and even exercises in water recovered efficiently. Dubin*et al.* [18] investigated that the patient could start with the available range of motion (ROM) with weight-bearing resistance exercises. These exercises could start with submaximal isometric strength exercises and progress to isotonic strengthening and finally progress into eccentric exercises, which places the greatest force on the muscles. Ankle disc training should be included which helps to improve balance and proprioception with a sequence of ankle stability exercises [18]. An ankle sprain had been found to have considerably reduced the balance when compared to control groups. The patient should start with light activity exercises on an even surface, then progress to more advanced balance exercises [18]. In the remodeling phase of healing functional movements should be used to re-establish the tensile strength and proprioception. The patient was ready for this stage of rehabilitation when he had achieved ROM, no pain and about 80% strength gained in comparison to the contralateral leg. These exercises started from simple to complex level on both legs providing the patient had no pain or swelling during/after the exercises [18]. Riva et al. [59] carried out a study on players of explosive activity that emphasized that ankle sprained had a negative effect and their kinetic motion is ceased. The researcher conducted the whole rehabilitation process by setting the parameter from initial to the final step, which emphasizes, manipulate and investigate the intrinsic and extrinsic factors of the whole study.

2.3 Hypothesis

The Study hypothesized that rehabilitation through the Headway Rehab exercises on ground (Isometric, isotonic and proprioception) is an effective method and cut down the recurrence.

3. METHODOLOGY AND PROCEDURE

Ninety-four male subjects were selected, their age was (15-35) years, having acute and chronic ankle sprain injury of duration 2 years (December 2016 to December 2018) passed through the Rest, Ice Compression and Elevation (R.I.C.E) protocol to get rid of initial pain (if needed). This study used a selective sampling technique. The data collected from 4 major cities (Lahore, Faisalabad, Gujranwala, Sialkot) of Punjab, having proper cricket facilities. The researcher endorsed the purpose of the study and signed their consent form. Age, weight and height measurements of the selected subjects were taken. The subjects were divided into the Control Injured group (N=48) and Headway Rehab Group (n=46) randomly. The subjects were medically fit except ankle sprain. The rehab exercise plan was executed in Punjab University Gym/ grounds, their respective clubs and private swimming pools. The data was normalized for the different heights of subjects, reach distances, the researcher calculated the normal values for the reach distances by dividing each direction by their respective height [17] and normality was checked through the Shapiro-Wilk test and found data was slightly normal. The test showed they were normally distributed. Probabilities of less than 0.05 were considered significant. SLB was considered to be a simple test. Forty Normal Control subjects were also taken for further comparison. Pre and post-exercises were executed and evaluated through SEBT and SLB test for dynamic and static balance. The subject executed the Headway exercises plan on non-injured and injured leg. Before starting the test, subject was given a verbal and visual demonstration and they performed six practice trials as recommended by Gribble et al., [17]. The test was evaluated by standing on the star grid on even and flat surface. The star grid was drawn by using a protractor, white tape and a measuring scale(tape) with eight lines marked out from the center at 45º angle and their names as according to the reach from the standing leg directions (anterolateral, anterior, anteromedial, medial, posteromedial, posterior, posterolateral, and lateral). The subject was asked to stand in the middle of the grid and touch the lines with his toe (non-injured and injured leg) in all eight directions. The maximum reach of each direction was measured in centimeter. The Single Leg Balance Test was executed as subject standing on single leg near a wall (support) and time has been noted in seconds. The test was discarded if the subject was unable to balance his body and foot could not touch the ground and both the tests were repeated thrice, average of 3 values were taken in order to avoid any discrepancies [17]. The grid is shown in Fig.1.

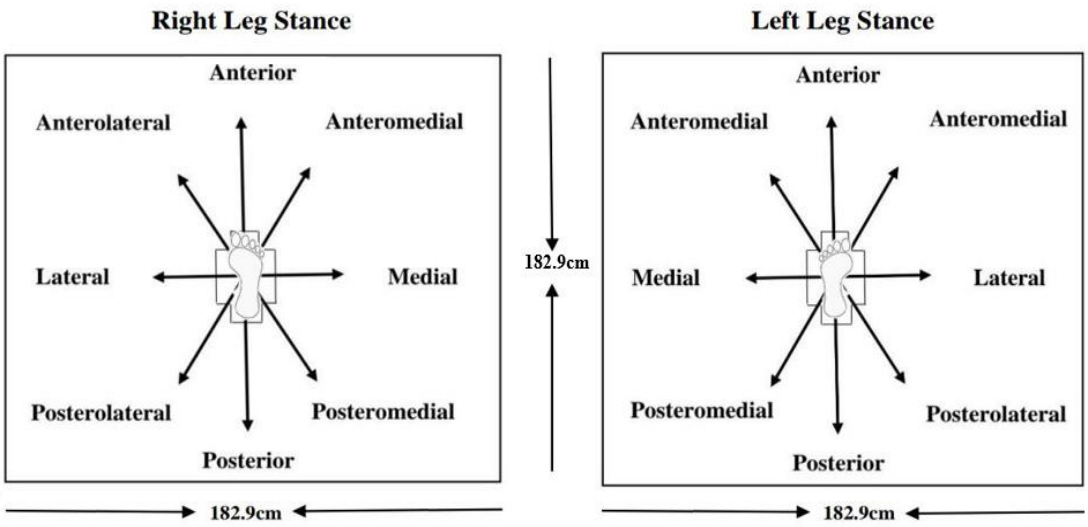

Fig. 1. Showing 8 directions (anterolateral, anterior, anteromedial, medial, posteromedial, posterior, posterolateral, and lateral) of the star excursion balance test of Right/Left leg stance [8]

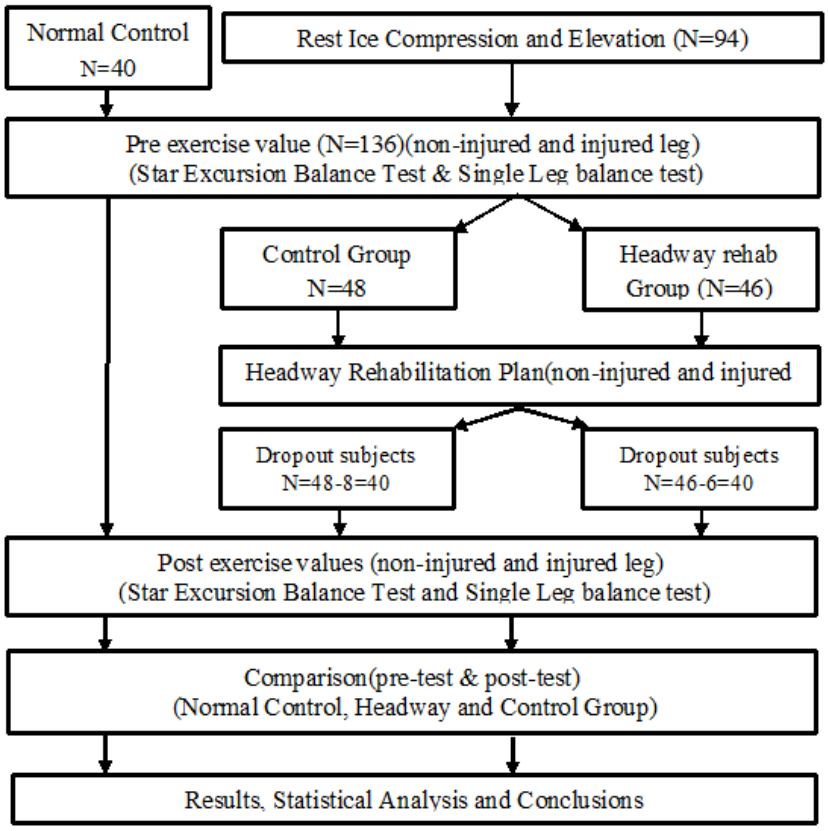

Fig. 2. Showing activities of amateur cricketers (N=94) with Acute and Chronic Ankle Sprain consisted of Normal Control (NC,40), Control Injured (CI,48), Headway Rehab Group (H,46) for Rehabilitation exercise plans for 8 weeks of duration, Subjects were selected from four major cities of Punjab from December 2016 to December 2018

The subject was standing on non-injured and injured leg on a hard surface near a support as much as the participant can in seconds with open and closed eyes. The time was noted in seconds and values had been observed for further comparison. The subject was given 3-5 minute rest to repeat the same process for the other leg. Eight subjects from the Control Group and six subjects from the Headway Rehab Group have left and did not available for the final post-testing. The cricketers enrolled in the rehab program started with 2-3 sessions/week were executed with duration of (25-30) minutes for 8 weeks. Principle of progression, overloading and specificity principles was utilized. The Fig. 2 showed the flow chart of the study.

The test was discarded if (a) Subject was unable to maintain his balance. (b) Foot displaced while performing the test; heels off and toes off of the floor. The exclusion criteria were that the cricketers were medically fit except ankle sprain. Isometric strength training, Isotonic strength training, proprioception and Sports specific training were executed in 24 sessions within the time frame of 8 weeks (3 days/ per week) as a rehab exercise plan and its duration was 30-45 minutes as the rehab program proceeded.Control group (CG) did not get any sort of the treatment and they were on medicine as prescribed by the physician.

3.1 Data Analysis

The data were expressed as Mean ± Standard deviation analyzed using SPSS (Statistical Package for Social Sciences) Ver.22 (SPSS Inc. Chicago, II, USA), SEBT and SLB test were analyzed using paired sample t-test [60].

4. RESULTS

4.1 Headway Rehab Group

Before starting, Headway rehabilitation plan the subjects (N=46) were evaluated through Star Excursion Balance Test (SEBT) and Single Leg Balance Test (SLB) for non-injured and injured legs. These values were denoted as pre-exercise values. This group executed hydro exercises for the duration of eight weeks. In this duration 6 subjects left the study due to their personal reasons, leaving behind 40 subjects.

4.2 Headway Rehab Group (Individual Improvement)

The difference between pre and post-exercise results of non-injured leg of the Headway rehab group tested through Star Excursion Balance Test indicated that there was an improvement (2.5 ± 0.5)% in eight directions. Mean ± S.D. values for pre-exercise (N=46) and post-exercise (n=40) showed a change from 66.0 ± 5.4 to 69.4 ± 5.5 with a difference of 3.6 ± 0.7. It showed a mean difference in pre and post-exercise results of the Star Excursion Balance Test (injured leg) with an improvement in all directions. Mean ± S.D. of subjects showed that their pre-exercise (N=46) and post-exercise (N=40) values changed from 66.1 ± 4.6 to 71.8 ± 4.9 with a difference of 5.8 ± 3.7 thereby showed percentage increases of 2.5 ± 1.6. The percentage change between pre and post-exercise results of non-injured leg through Single Leg Balance Test indicated that there was an improvement in both positions (closed and open eyes). Mean ± S.D. values of subjects with non-injured leg, changed from 72 ± 3.6 to 74.9 ± 2.6 with a difference of 3.9 ± 2.5 thereby showing percentage of 1.0 ± 0.7. The difference between pre-exercise (N=46) and post-exercise (N=40) values for a Single Leg Balance Test of injured leg, showed an improvement (2.5 ± 0.9)% while balancing with closed and open eyes. These values changed from 43.7 ± 5.5 to 55.8 ± 5.2 with a difference of 13.4 ± 4.7 respectively.

4.3 Headway Rehab Group (Star Excursion Balance Test)

The subjects in Normal Control (CI=40) did not performed any special exercises but they were resuming their normal activities. However, their pre and post-exercise value (Star Excursion Balance Test) of eight directions were noted. Their data analyzed by paired sample t-test and were found statistically significant for lateral ($p<0.05$), posterior, posteromedial and medial direction ($p<0.001$), while such values were found nonsignificant for four directions (anterior, anterolateral, posterolateral and anteromedial) further details are shown in Fig. 3 (A).

The subjects in Control Injured group (n=48) were having acute or chronic ankle sprain of one leg. They were at rest and medications as recommended by their doctors. The subjects were evaluated for non-injured leg, pre-exercise values of eight directions of Star Excursion Balance Test and 8 subjects left the study due to their personal reasons. After 8 weeks, the leftover 40 subjects were evaluated for their post exercise evaluation for non-injured leg for 8 directions of SEBT test. Statistical analysis of pre exercise and post exercise evaluations were

noted significant for lateral ($p<0.001$), medial direction ($p<0.05$), remaining six directions (anterior, anterolateral, posterolateral, posterior, posteromedial and anteromedial) were showing non-significant changes in their pre exercise and post exercise values (Fig. 3 (B)). Pre-exercise (n=48) and post-exercise (n=40) evaluations for the subject in Control Injured group (for their injured leg) were noted and found statistically non-significant for anterior, anterolateral, lateral, posterolateral, posterior, medial and anteromedial directions. The results for remaining one direction (posteromedial) was found statistically significant ($p<0.05$) (Fig. 3(C)).

Although the subjects in Headway Rehab Group (n=46) were with acute and chronic ankle sprain for one leg. Their SEBT values for the eight directions of SEBT test (pre-exercise) for non-injured leg compared with the same values after completing 8 weeks of isometric strength, isotonic strength and proprioception exercises (i.e. the post-exercise) values were found statistically significant ($p<0.001$) for all the directions of SEBT grid. Thereby showing significant improvement (Fig. 3(D)). However, the present increase for all the eight directions were within the range of 3.7- 4.8 (Fig. 3(D)). Pre-exercise (n=46) and post-exercise (n=40) values for an injured leg (acute and chronic ankle sprain) were found statistically significant ($p<0.001$) for all eight directions of SEBT grid. The present increase of all the directions was within due range of 4.2-5.5. The positive impact of proposed Headway exercises method is visible (Fig. 3 (E)).

4.4 Headway Rehab Group (Single Leg Balance Test)

The difference between pre-exercise and post-exercise values (sec) evaluated through Single Leg Balance Test (SLB) of Normal Control (n=40) was noted statistically significant ($p<0.05$) while balancing with closed eyes and open eyes ($p<0.01$) as shown in Fig. 4.(A). Control Injured Group (non-injured leg) showed non-significant improvement in their pre-exercise and post-exercise values (sec) while balancing with closed and open eyes as the Mean ± S.D. values decreased from 35.1 ± 2.7 to 34.3 ± 2.4 and 33.2 ± 2.2 to 33.1 ± 2.4 respectively (Fig. 4.B). Similarly, values for the injured leg were found non-significant while balancing with closed eyes and open eyes (Fig. 4.B). The change of percentage between pre and post-exercise of the Headway rehab group results through Single Leg Balance Test indicated that there was an improvement of 44.9 and 75.3 percent in both positions (closed and open eyes). Mean ± S.D. values (seconds) of subjects non-injured leg (closed eyes) changed from 20.7 ± 2.7 to 30.8 ± 2.1 with a difference of 10.1 and the injured leg 16.6 ± 2.7 to 29.1 ± 2.7 with a difference of 12.6 as shown in (Fig. 4.C). Subjects in the Headway rehab group were evaluated after 8 weeks of the proposed method of Headway exercises (dorsiflexion, plantar flexion, isometric holds against the wall, inside and outside isometric hold, plantar and dorsiflexion mobilization, single leg stance with closed eyes and open eyes) on ground and gymnasium as well. Their pre-exercise and post-exercise difference in the values (seconds) of injured leg showed a difference of 12.7 and 51.6 while balancing with closed and open eyes respectively. The data analyzed by paired sample t-test, was found statistically significant ($p<0.001$) for both values (Fig. 4.C).

5. DISCUSSION

This study revealed that each excursion (direction) activated the stance of the lower extremity muscle to a different extent through improvement in the muscle activation as assessed through Star Excursion Balance Test (SEBT) and Single Leg Balance test (SLB) and Headway rehab group played a vital role in regaining strength, position sense of ankle joint and also in improving functional stability. The primary finding of the Headway rehab study was that the 8 weeks of rehabilitation through strength (isometric and isotonic) and proprioception along with theraband exercises, improved strength of supporting ankle joint muscles in 8 directions of SEBT and 2 positions of SLB. The pre and post-exercise deduced a significant improvement in ankle sprain functions.

The result of this study indicated that cricket players' rehabilitation plan of eight weeks with Headway exercises regained their range of motion (ROM) isometric and isotonic strength; improved their flexibility and proprioception. This result is consistent with the findings of Simon et al. [61]. The Headway rehab part of this study exploited amateur cricketers for isometric and isotonic strength training of ankle gait, along with proprioception and theraband exercises which resulted in the improvement of ankle functionality and balance. Mattacola and Lloyd [62] and Docherty et al. [26] also reported similar findings that an arrangement of strength and

proprioception exercises may help us to develop/improve dynamic balance as they studied the ankle sprain athletes of different profession.

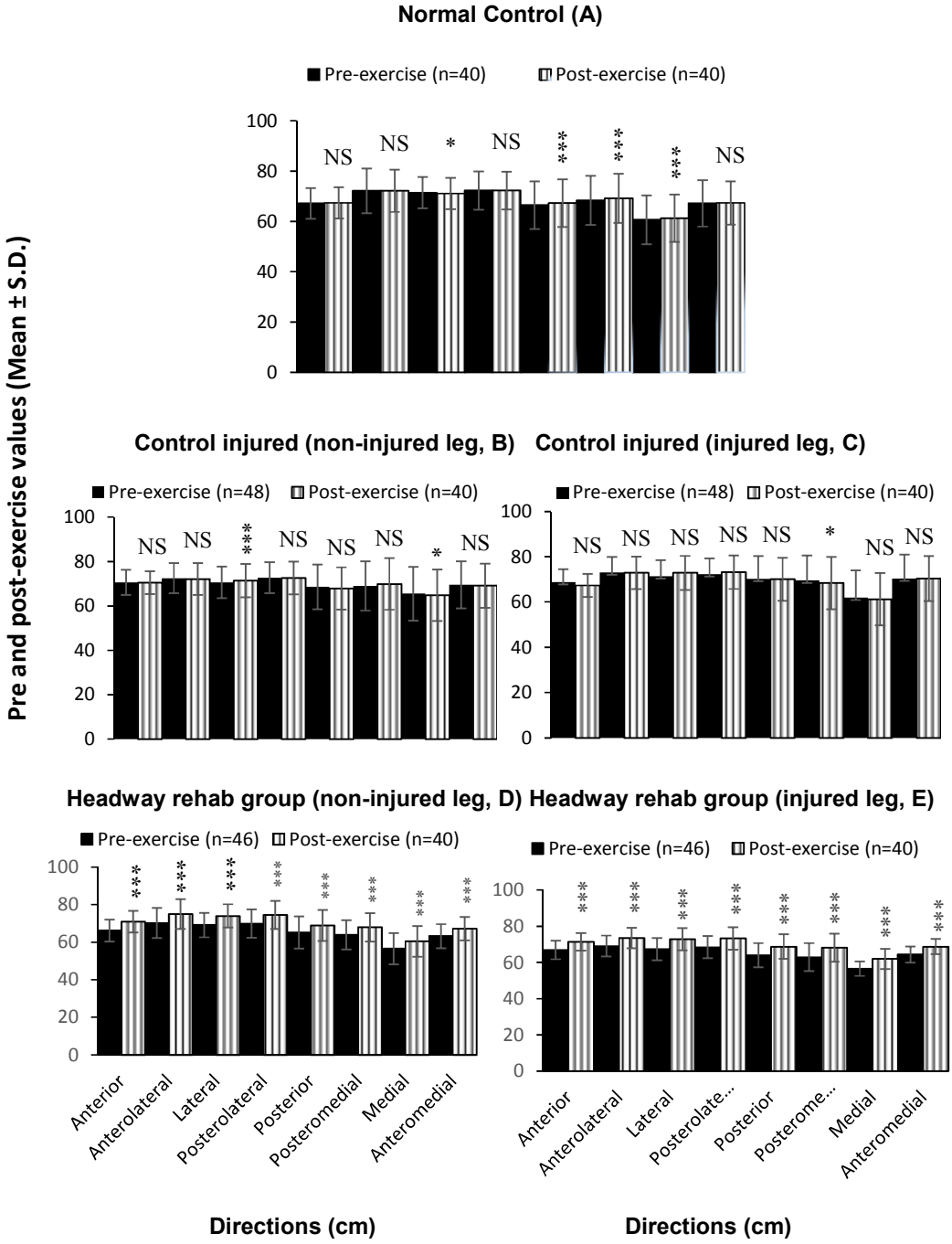

Fig. 3. Showing Mean ± S.D. of pre exercise and post exercise values (cm) of 8 directions were evaluated by Star Excursion Balance Test (SEBT) of Normal Control (A), Control injured (non-injured leg, B; injured leg, C), Headway Rehab Group (non-injured, D; injured, E). The subjects were selected from four major cities of Punjab from December 2016 to December 2016. The data compared and evaluated by paired sample t-test, was found statistically significant at *p<0.05; **p<0.01; ***p<0.001 level

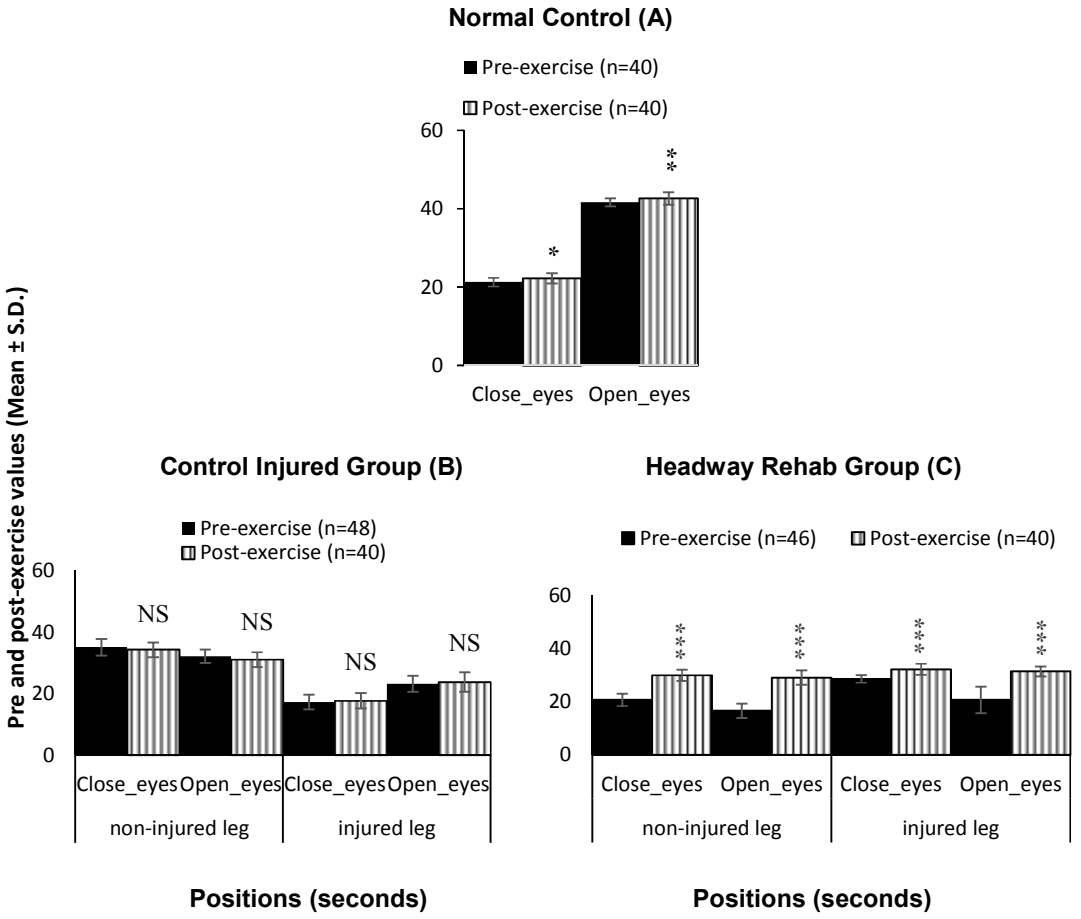

Fig. 4. Showing Mean ± S.D. of two positions balance with close eyes and open eyes of Single Leg Balance Test of subjects in Normal Control (A), Control Injured (B) and Headway rehab group (C). Subjects were selected from four major cities of Punjab from December 2016 to December 2018. The data compared and evaluated by paired sample t-test was found statistically significant at *p<0.05; **p<0.01; ***p<0.001 level

Similarly, the Headway results of this study showed that strength exercises improved balance and proprioceptive sense on stable ground. This trend can also be seen in a study by Ha et al. [63] based on the treatment of adults with a chronic ankle sprain, however, they utilized unstable surface for strengthening exercises. The present study also showed that the rehabilitation through a combination of strength (isometric and isotonic) and proprioception training along with progression was effective for ankle sprain recovery. This finding seems similar to the conclusion of Mattacola and Dwyer [29] in relation to their work on the rehabilitation of ankle sprain athletes. Similarly, 24 sessions of isotonic strength training improved the strength, which is similar to the findings of Tsaklis and Abatzides [64] based on his work on knee rehabilitation.

This Headway rehab study emphasized on proprioception and strength training of ankle supporting muscles and found that it reduced the recurrence rate of an ankle sprain. Similar findings can be found in the work of Willems et al. [31] as they concluded that proprioception and ankle muscle strength training may decrease recurrence rate while they worked on physical education students. The study also utilized the principle of overloading, specificity and progression along with a comprehensive rehabilitation program. This plan of rehabilitation is in line with the conclusion of Hale et al. [65], which highlights that the progression and ample rehabilitation minimizes lower extremity reach deficits. Furthermore, Sekir et al. [66] also used strength and proprioception protocols for an improvement in ankle functionality among athletes. The Headway rehab part of the study

concluded that the overall improvement of the group was 2.5% for both non-injured and injured leg respectively. The result was in line with other scholars which demonstrated that strength training improved strength. For example, Smith et al. [39] shared similar views based on their work on volunteered active and healthy college students.

This Headway rehab study concluded that strength is an essential component for the rehabilitation of ankle sprain, as due to muscle weakness, athletes have greater chances of recurrence ankle sprain injury. Therefore, it is necessary to strengthen the ankle supporting muscles (lower extremity) through isometric and isotonic strength exercises as it was also reported by Hall et al. [45] that strengthening program not only focused on the ankle but also emphasized on entire lower extremity muscles during their study on university students with ankle instability.

This Headway study also proposed that due to a combination of strength (isometric and isotonic) and proprioception training resulted in an improvement in dynamic balance and strength as it was assessed through SEBT. The results were similar to the findings of Hall et al. [52] as they concluded that both strength and balance training can improve the strength and functional performance of ankle sprain of athletes. They also revealed that the combination of resistance band along with proprioception and strength training was an effective procedure for the rehabilitation of ankle instability [52]. It was extracted from this Headway rehab study that isometric and isotonic strength, proprioception and utilization of theraband improved ankle stability, strength, joint position sense, range of motion and functionality. This result is consistent with the findings of Alahmari et al. [54] based on their work on ankle instable patients belonging to different age groups.

The Headway study revealed that the individual subject's improvement was 2.2% which is more than non-injured leg as compared in the case of SEBT protocols.

5.1 Single Leg Balance Test (SLB)

The present study resulted that subjects of poor balance also causes the ankle sprain problem. Our 24 sessions of Headway rehab training program showed an improvement of strength and proprioception, assessed through SLB for static balance respectively.

The Headway rehab study regarding ankle sprain stated that a decrease in the performance of the Single Leg Balance (SLB) positions was due to the overuse of the hip abductor muscles. This result is in line with Gribble and Hertel [67], Paterno *et al.* (2004) and Holmes and Delahunt [68]. Likewise, the present study of Headway rehabilitation highlighted that anterior tibialis activation improved ankle dorsiflexion, which is similar to the results of Blanchette et al. [69] as they worked on the rehabilitation of ankle dorsiflexion. Furthermore, Chang et al. [70] stated that hip abductor muscle performance correlates with standing balance performance [67]. SLB test showed that the improvement in the non-injured leg was 55.9% more active as compared to the injured leg (closed and open eyes). Five subjects were injured during the 24 sessions implementation of the Headway rehab program, there recurrence rate was approximately 17.5% in the control injured group and 12.5% in the Headway rehab group which were followed for 4 months after the rehabilitation exercise plan.

6. CONCLUSION

The study concluded that 8 weeks Headway rehabilitation exercises (dorsiflexion, plantar flexion, inversion movement eversion movement and mobilization walking and jogging) significantly reduces pain and recovers efficiently, regain strength, reinstall proprioception and moreover reduce the risk of future ankle sprain by follow the subjects for four months to check the recurrence 17.5% in control injured group and 12.5% in Headway Rehab Group. It is due to the Headway exercises that improvement in strength and stability of the muscles that support ankle. However, further studies in this connection are needed.

CONSENT AND ETHICAL APPROVAL

As per international standard or university standard guideline patients consent and ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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