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Chronic Ankle Instability: Therapeutic Exercise and Data Analysis

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Abstract

Background and Objectives: Ankle injuries are the most common type of injury in healthy active individuals. If not treated properly, recurrent sprains can lead to a condition of chronic ankle instability (CAI). The present paper examines some subjects with a previous history of acute inversion ankle sprain who have developed a subsequent condition of instability, grouping them according to inclusion criteria and analyzing them through four field tests considered objective by the scientific literature: SEBT test, BEES test, TIBT test, SHT test. The data obtained were stored in order to compare them following a re-education protocol aimed at improving proprioception, balance, walking and strengthening the extrinsic and intrinsic muscles of the foot. per year. The subjects were then divided into two categories: subjects with CAI > 1 year and subjects with CAI ≤ 1 year. A protocol lasting 6 weeks was administered to both groups, trying to work on improving balance in single stance, improving static and dynamic stability, strengthening the gluteus medius and maximus (pelvis stabilizers) and strengthening of the intrinsic muscles of the foot. At the end of the protocol the subjects were all re-evaluated with the same field tests used previously and the data obtained were compared both with the pre-protocol data and with the data measured by the control subjects.

Keywords

Ankle Instability, Ankle Sprain, Ankle Injuries, Exercise

1. Introduction

The ankle, anatomically, is an unstable joint complex, as it is subjected to stresses which tend, in particular, to varus deviations. This instability is due to the loss of alignment and biomechanics, which should be guaranteed by 28

bones, enclosed in a very thin envelope offered by soft tissues, with little possibility of slipping.

The foot-ankle system is able to effectively and efficiently dissipate the compressive shear and rotational forces to which the organism is subjected when standing. Therefore, the aid of the ligament and muscular components is fundamental, due to the excessive dynamic stresses that the joint undergoes.

The anterior talofibular ligament controls and limits the "talor-tilt"; while the two tibia-persona and astragalo-calcaneus complexes slide reciprocally without posing any resistance compared to the inextensible segments, corresponding to the anterior peroneal-talar ligament and the peroneal-calcaneal ligament.

The foot is a very complex structure, it allows us to relate to the environment thanks to its high proprioceptive capacity, but it must also act as an organ of motion by managing the body weight during dynamics, adapting to irregular surfaces and bringing both the descending forces than ascending forces; which is why the structure of the foot is studded with muscular and joint structures positioned in such a way as to be able to absorb and redistribute the various forces to which they are subjected. Foot pain is very common in the general population with particular incidence in subjects over 65 years of age, in obese and overweight subjects and in female subjects. In the USA, approximately 2 million acute ankle sprains occur every year and, among the main risk factors, in the general population, we find a deficiency in the functional performance of the foot-ankle complex, incorrect walking, falls, etc. Ankle injuries in the sports population, however, are extremely common, with percentages around 30%, up to 75% - 80% in sprain-type traumas, with greater frequency for inversion sprains. Inversion sprains are more common in individuals who practice amateur and professional sports. Sprains also boast a high rate of recurrence associated with the development of chronic ankle instability. (1)A meta-analysis estimated the incidence rate of lateral ankle sprain of 0.93/1000 among athletes participating in the competition, while an incidence rate of 0.06 and 0.38/1000 for acute medial and high syndesmotic sprains respectively. More than ¾ of ankle sprains are lateral and approximately 73% of these have injuries to the anterior talofibular ligament. Several studies have highlighted how subjects with a previous history of sprain had a risk of recurrence 3.5 times greater than the standard population (approximately 40% of subjects who have suffered a LAS develop CAI). Similar to the analyses on ankle sprain, CAI also shows a higher incidence in females, with 32% compared to 17% in males. [1] [2]

As regards injuries, ankle ligament injuries are the most common and most frequently seen in the emergency room. Covering approximately 25% of the lesions of the musculoskeletal system are the lesions of the anterior talofibular ligament, which presents itself as an unusual lesion in 50% - 75% of cases, with association with the lesion of the calcaneal fibular ligament, in major traumas which correspond to a percentage ranging from 15% to 25%. [3]

The different bone components form all the joints that make up the structure of the foot (Figure 1).

- Subtalar joint (talar-calcaneal).

- Chopart's mid-tarsal joint ◊ the "S"-shaped Chopart's interline, extended between the talonavicular-scaphoid and calcaneocuboid joints. The ligaments that stabilize the interline of Chopart are the dorsal, internal and plantar calcaneocuboid ligaments.

- Scapho-cuboid joint.

- Scapho-cuneiform and intercuneiform articulation.

- Lisfranc tarsometatarsal joint.

- Metatarsophalangeal and interphalangeal joints.

Other ligament structures that intervene in stabilizing this joint are:

- Anterior talonavicular ligament: extended between the lower surface of the talus and the upper surface of the calcaneus, anterior to the articular surfaces. [3] [4]

- Lateral talonavicular ligament: extended from the external face of the talus to the external face of the calcaneus.

- Posterior talocaneal ligament: extended from the postero-external tubercle of the talus to the posterior surface of the calcaneus. [5]

2. Materials and Methods

- Balance Error Scoring System (BESS)
- Star Excursion Balance Test(SEBT)
- Time in Balance Test(TIBT)
- Side-Hop Test (SHT)
- Table 1. (The reset Table 1. Research was subjected to the following inclusion and exclusion criteria)

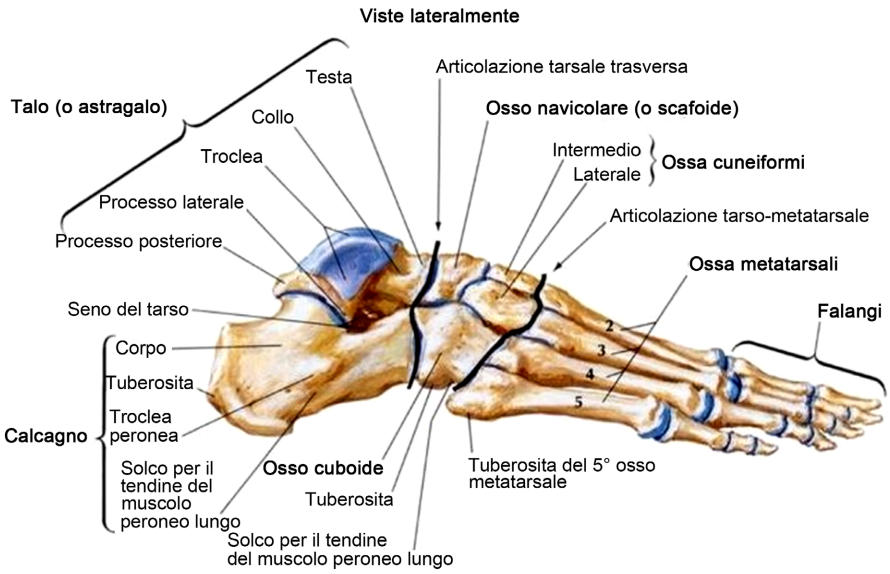

Figure 1. Anatomy of the foot.

Table 1. RCH was subjected to the following inclusion and exclusion criteria.

INCLUSION CRITERIA	EXCLUSION CRITERIA
Positivity in field tests	*Negative in field tests*
History of ankle sprain in reversal undergone within ≥ 1 *year*	*Grade* ≥ *1 sprain and surgically treated sprains*
Grade 0 *distortion*	*Age* < 20 *years or* > 30 *years*
Age ≥ 20 *years* ≤ 30 *years*	*No instability was detected in tests by the field*

Once the subjects who represented these characteristics were identified (**Table 1**), they were administered the following tests at time T0, T1 and subsequently to the protocol (T2), carefully constructed for each subject [6].

2.1. SEBT

Test widely used in sports and physiotherapy to evaluate dynamic postural control in athletes. In addition to being a valid indicator of dynamic stability, the Star Excursion Balance Test has proven to be a sensitive indicator of the risk of lower limb injuries in a variety of subjects. [7] [8]

The SEBT measures the subject's dynamic balance when balancing on a single limb, trying to reach the furthest point possible in eight different directions (**Figure 2**). The literature has shown that SEBT scores are significantly different in subjects with lower limb trauma (such as CAI) compared to healthy subjects; Furthermore, this test is a valid aid in evaluating the dynamics following a rehabilitation and re-education protocol. [8] [9] The test is performed in a safe environment and without external disturbances that could alter performance. Place a star on the floor, using adhesive tape, representing the eight directions, at least 60cm long each, arranged one from the other at an angle of 45˚ as shown in the figure below. [9] [10]

Participants perform the test barefoot, starting from the center of the star, waiting for the instructions provided by the examiner. If you start with the left limb supported, the turn will be carried out in a clockwise direction, on the contrary, with the right limb supported, the turn will take place in an anti-clockwise direction.

2.2. BESS

The BESS test is an economical and objective clinical test used to evaluate the individual's static global postural control, originally used to evaluate postural stability in athletes with head trauma and adapted for the evaluation of conditions such as stability following fracture of the ACL or in case of ankle instability and other conditions (**Table 2**). The BESS evaluates the number of "errors" that are made by the subject while maintaining balance for 20" in 6 different conditions such as bipodal support (with feet in contact), monopodal support (on a non-dominant limb) and tandem support (non-dominant limb posteriorly), car-

ried out both on rigid flooring and on soft flooring (on BALANCE PAD 40 × 33 × 6 cm). [11]

In all conditions, you are asked to keep your hands on the iliac crests, your head in a neutral position and your eyes closed. The tests were carried out without the interference of light and sound stimuli so as not to alter the execution of the test.

The types of errors that can be made by the subject are listed in **Table 3** below:

The BESS score is between 0 and 60 (low scores indicate fewer errors, therefore a better balance). The maximum number of errors for each individual condition is 10. If the subject fails to maintain the test position for a minimum of 5", the maximum score for that category is assigned [10] [11] [12].

The total test administration time is around 10'.

The range of optimal values for this test differ according to age groups: performance in the BESS improves as a function of age, and then declines at advanced ages, particularly after the age of 50. The BESS score increases with fatigue (12). The assessment of static postural control is important in the clinical management of

Lateral ankle sprain, in particular, balance deficits are frequent especially in subjects with CAI, showing greater errors in single limb tasks and in tandem position, both on a rigid platform and on a soft platform [12] [13].

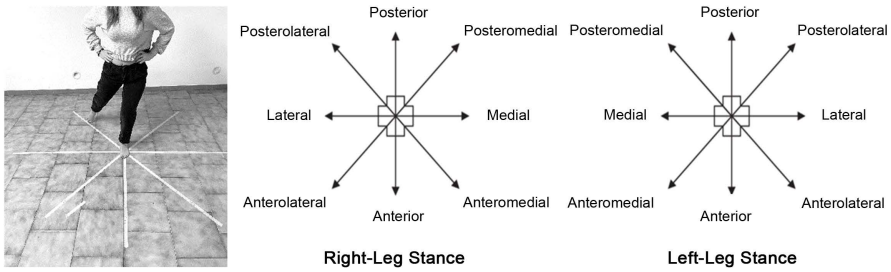

Figure 2. Example of SEBT.

Table 2. BESS-Types of errors.

BESS- Types of errors
Eyes open
Eyes open Displacement from the test position (steps forwards/backwards; stumbles; falls)
Movement of the hands from the iliac crests
Hip movement > 30˚ of flexion or abduction
Rearfoot or forefoot lift
Alteration of test position > 5"
The BESS score is calculated by adding 1 point for each error in the 6 parameters during the 20" test

* *if the subject makes multiple errors at the same time, only 1 point is added.*

Table 3. Tibs.

ETÀ	*PUNTEGGIOMEDIO*
5-23 ANNI	Punteggio totale: ±13 (3suappoggiostabile,10suappoggioinstabile)
20 - 39 ANNI	Punteggio totale: ±11
40 - 49 ANNI	Punteggio totale: ±12
50 - 54 ANNI	Punteggio totale: ±13
55 - 59 ANNI	Punteggio totale: ±15
60 - 64 ANNI	Punteggio totale: ±17
65 - 69 ANNI	Punteggio totale: ±20

This test is used to measure participants' single-foot balance time. The test is performed barefoot with hands on the iliac crests, performing three tests with eyes open and three with eyes closed. Participants must try to remain as still as possible while balancing on a single limb for 60". However, the test can be interrupted before 60" if there is a loss of balance, understood as touching the suspended foot with the ground. Only the best time recorded in the 3 tests with eyes open and eyes closed are recorded. Deficits in static balance are present in subjects with CAI, presenting poorer balance when compared to healthy control subjects [14] [15].

2.3. SIDE HOP TEST

Dynamic test based on the execution of 4 functional tasks (**Figure 3**): side hop; up-down hop; single hop; figure-of-8-hop.

- Figure-of-8-hop (A): test performed on a 5 m long path, marked by two cones. Participants must jump with only one limb (injured limb) as fast as possible by performing two turns.

- Side hop (B): test performed using single-leg lateral jumps (injured limb) of 30cm distance for 10 total repetitions. [16]

- Up-down hop (C): test performed by jumping up and down (injured limb) on a platform of approximately 20cm. A total of 10 repetitions are performed.

- Single hop (D): execution of a single jump forward, trying to reach the greatest distance possible. The distance is measured from the big toe to the starting point and to the point of contact following the jump.

Each test is monitored to the second via a stopwatch, keeping a margin of error of 0.01". Each test is performed twice, recording the best time and longest distance achieved. A 30" rest is administered between the two tests, with a maximum of 1' between one test and the other [17].

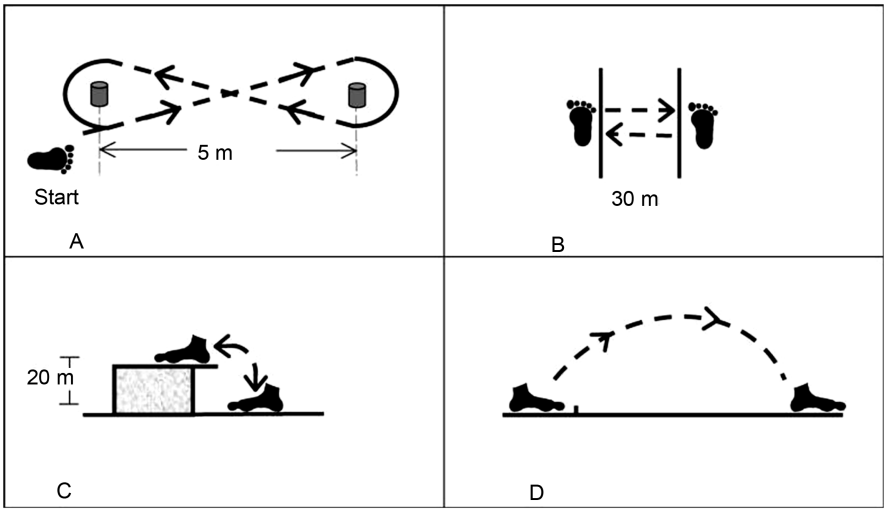

Figure 3. Dynamic test based on the execution of 4 functional tasks.

2.4. Survey

Participants were asked to complete a questionnaire relating to the sensations perceived during the tests. Several researchers have implemented the use of questionnaires with the aim of verifying whether the subjects' perceptions were altered in the execution of functional tasks, showing a positive correlation. Therefore, after each test performed, participants were asked if they perceived instability in performing the task. [17] [18]

Re-education protocol tailor-made for experimental athletes with ankle instability (Table 4-5):

Table 4. WARM-UP – (if possible, 5' general warm-up on treadmill/exercise bike).

ESERCIZIO	SETERIPETIZIONI	INFO
CIRCONDUZIONI CAVIGLIA	20 circonduzioni x lato	Esecuzione lenta e controllata
CALF BIPODALICO SU SUPERFICIE SOLIDA (PARTENZA DA TERRENO)	20 ripetizioni x 1 volta	Esecuzionel enta e controllata in full ROM articolare
CAMMINATA SU PUNTE E SU TALLONI SU SUPERFICIE IBRIDA	10 ripetizioni sulle punte + 10 ripetizionisuitalloni x 3 giri	Esecuzione lenta. Piazza untappetino lungo il percorso eseguendole ripetizioni sulle puntee sui talloni passando dalla superficie solida a quella morbida.

Table 5. Strengthening extrinsic-intrinsic foot muscles.

ESERCIZIO	SETERIPETIZIONI	RIPOSO
CALF MONOPODALICO CON TAPPETINO SU STEP/GRADINO	4 set da 12/15 ripetizioni	60"
EVERSIONE DI CAVIGLIA CON ELASTICO	4 set da 12/15 ripetizioni	60"
INVERSIONE DI CAVIGLIA CON ELASTICO	4 set da 12/15 ripetizioni	60"

Continued

FLESSIONE DORSALE DI CAVIGLIA CON ELASTICO	4 set da 12/15 ripetizioni	60”
CALF MONOPODALICO CON STABILIZZAZIONE IN EVERSIONE DI CAVIGLIA	4 set da 10ripetizioni	60”
AFFONDO STATICO SU TAPPETINO	4 set da 12ripetizioni	60”
STABILIZZAZIONE DINAMICA GLOBALE MONOPODALICA	4 giri (esecuzione lenta e controllata)	60”
RINFORZO MUSCOLATURA INTRINSECA DEL PIEDE	4 set da 10/12 ripetizioni	60”

Each monopodal exercise must be performed with both limbs, starting with the injured limb.

REMEMBER! EACH EXERCISE MUST BE PERFORMED WITH BAREFOOT, WITHOUT THE USE OF SOCKS OR SHOES

In association with the written protocol, all participants were sent executive videos of the various exercises.

3. Description of Exercises

Place a mat (double folded) above a step or step and raise it SLOWLY on the toes with a 1” stop. Then perform a CONTROLLED descent to the maximum possible ROM (without feeling pain) and repeat again later for the indicated repetitions. [19]

The knee should be kept extended (**Figure 4**).

If it is difficult to perform it single-legged, opt for a two-legged execution or, if the problem still persists, opt for a seated execution with a light load on the knees or, further seated with an elastic band, first setting a resistance in dorsal flexion and then in plantar flexion.

- Ankle eversion with elastic

In a sitting position with your leg extended, wrap an elastic around the central part of the foot (the elastic must be fixed to a protrusion), at this point distance yourself a minimum from the fixation point so as to slightly tighten the elastic. The entire lower limb remains fixed on the ground, the movement must be performed EXCLUSIVELY with the ankle, directing the foot outwards/upwards. [20]

- In a sitting position with your leg extended, wrap an elastic band around the part (**Figure 5**)

center of the foot (the elastic must be fixed to a protrusion), at this point, distance yourself a minimum from the fixation point so as to slightly tighten the elastic. The entire lower limb remains fixed on the ground, the movement must be performed EXCLUSIVELY with the ankle, directing the foot inwards/downwards. [21]

Figure 4. Two-legged/single-legged calf on an unstable surface (mat).

Figure 5. Ankle inversion with elastic.

- Ankle dorsiflexion with elastic (**Figure 6**)

In a sitting position with your leg extended, wrap a rubber band around the middle of your leg foot (the elastic must be fixed to a protrusion), at this point distance yourself a minimum from the fixation point so as to slightly tighten the elastic. The entire lower limb remains fixed on the ground, the movement must be performed EXCLUSIVELY with the ankle, pulling the foot towards you. [21] [22]

In a monopodal stance, with an elastic positioned around the ankle and fixed laterally to it (simulates the injury mechanism), you are required to stand on the tip of your foot, resisting the external force while keeping the structure stable. Keep the climb on tiptoe for 1-2". [21] [22] [23]

Position one limb in front and one in the back (the distance must not be excessive); the front foot, corresponding to the injured one, rests on an unstable surface provided by a mat (if it is too thin it must be folded up), at this point a lunge is performed at a controlled speed, trying to keep the joint structures stable (**Figure 7**). [23] [24]

Figure 6. Monopodial calf with ankle stabilization in eversion.

Figure 7. Static lunge on an unstable surface (mat).

In monopedal support on the ground, you are asked to touch some points marked in front of the subject, trying to move them slightly forward with your foot (**Figure 8**). Once performed, you are asked to try to catch the objects with your hands, always remaining balanced on the supported limb. The contralateral limb must not rest on the ground, the ideal would be to position yourself above a small increase in the size of the foot. [24] [25]

In a sitting or standing position, you are asked to bring a towel closer with the flexion of the toes, also trying to increase the internal arch of the foot. It is also important to focus on accentuating the medial arch, as a common mistake is to flex the fingers exclusively, resulting in a simple curling of the towel. If the exercise is too easy, you can place a small weight on the end of the towel (**Figure 9-10**). [26]

4. Discussion

Data collection and evaluation of case subjects post-reeducation protocol: outcomes.

Figure 8. Single-leg global dynamic stabilization.

Figure 9. Strengthening the intrinsic muscles of the foot.

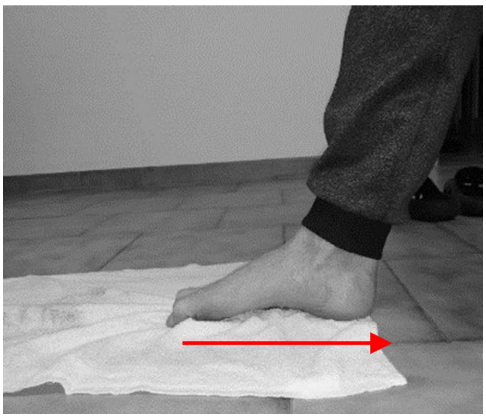

Figure 10. Foot exercise

The Time in Balance Test (TIBT) also highlighted improvements in terms of duration of static balance both in subjects with CAI ≤ 1 year and in subjects with CAI > 1 year. The TIBT data were analyzed by averaging the two highest scores obtained for each category: eyes open and eyes closed for both the left foot and the right foot, obtaining the following scores (Table 6).

Further confirmation is obtained if the values of the "case" subjects are compared with those totaled by the "control" subjects, grouped in Table 7 below. You can instantly notice how they are closer to the normative ones of the "control" subjects.

The two tests used to evaluate balance, stability and dynamic postural control are: SEBT and SHT. The Star Excrursion Balance test proved to be a rather difficult test for all the subjects tested, both case and control (to a greater extent the case subjects), however, after the administration of the 6-week re-education protocol the case subjects demonstrated less difficulty in the various test directions. The data showed that subjects with CAI ≤ 1 year improved postural control, stability and dynamic balance, while in subjects with CAI > 1 year the improvements were minimal if not zero in at least 1/2 of the 3 directions considered relevant in

Table 6. N.B. results with "*" indicate the limb that has suffered sprain trauma.

TIBT	***SOGGETTO1***		***SOGGETTO2***		***SOGGETTO3***		***SOGGETTO4***		***SOGGETTO5***	
	PRE	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*
OCCHIAPERTI	DX 60"	DX 60"	DX* 60"	DX* 60"	DX 60"	DX 60"	DX 60"	DX 60"	DX 28.57"	DX 60"
	SX* 51.5"	**SX* 60"**	SX 60"	SX 60"	SX* 32.47"	**SX* 60"**	SX* 60"	SX* 60"	SX* 47"	**SX* 60"**
OCCHICHIUSI	DX 37.85"	DX 57.95"	DX* 10.27"	**DX* 60"**	DX 34.6"	DX 19.72"	DX 60"	DX 60"	DX 16.21"	DX 58.6"
	SX* 35.7"	**SX* 60"**	SX 26.03"	SX 60"	SX* 13.02"	**SX* 16.65"**	SX* 24.34"	**SX* 60"**	SX* 36.2"	**SX* 57.05"**

N.B. results with "" indicate the limb that has suffered sprain trauma.*

Table 7. TIRB.

TIBT	***CONTROLLO1***	***CONTROLLO2***	***CONTROLLO3***	***CONTROLLO4***
OCCHIAPERTI	DX 60"	DX 24.15"	DX 60"	DX 60"
	SX 60"	SX 60"	SX 60"	SX 60"
OCCHICHIUSI	DX 23.99"	DX 11.89"	DX 60"	DX 60"
	SX 47.35"	SX 18.39"	SX 60"	SX 60"

the test. [26] [27] The data from the Star Excursion Balance Test (SEBT) were analyzed by averaging the two highest scores obtained with the injured limb, only in three of the eight directions required by the test, as scientific research shows a direct correlation "score-instability-recurrence risk", in the directions AM-M-PM (left foot supported) and AL-L-PL (right foot supported) in subjects with CAI. The results obtained from the analyzes are the following (**Table 8**).

Keeping reference to the normative values made available by the various studies analyzed, such as those conducted by Hertel, Miller and Deneger et. to the. (2000), from the study conducted by Plisky et. to the. (2006) and in the study conducted by Chaiwanischsiri et. to the. (2005), the scores obtained were analyzed to obtain the relative distance in each direction (%), a parameter considered a predisposing factor for relapses in subjects with CAI for values that do not fall within the range between 0.78 - 0.96 for some authors, while for others the range extends from 0.85 - 0.96. [28]

In **Figure 11** above it is possible to see how the control subjects are at a higher level of dynamic control than the case subjects, however, it can also be seen how the latter are closer (in particular in CAI subjects ≤ 1 year) to the control subjects after the 6-week protocol.

To conclude, in the last battery of tests which go by the name of Side Hop Test (SHT) the results obtained show notable improvements in terms of stability, safety in the task request, balance and postural control in dynamics compared to the pre-protocol data both in subjects with CAI ≤ 1 year and in subjects with CAI > 1 year (**Table 9**). [29] [30] [31]

Table 8. SEBT test.

SEBT	*SOGGETTO1*		*SOGGETTO2*		*SOGGETTO3*		*SOGGETTO5*	
	PRE	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*
Direzione AM	73.5	**78.8**	58.75	**67.55**	81.55	**88.25**	72.25	**75.35**
(antero-mediale)	±0.2	**±0.2**	±0.2	**±0.2**	±0.2	**±0.2**	±0.2	**±0.2**
	cm	**cm**	cm	**cm**	cm	**cm**	cm	**cm**
Direzione M	78.9	**74.55**	55.9	**66.9**	62.6	**79.8**	62.75	**65.05**
(mediale)	±0.2	**±0.2**	±0.2	**±0.2**	±0.2	**±0.2**	±0.2	**±0.2**
	cm	**cm**	cm	**cm**	cm	**cm**	cm	**cm**
Direzione PM	55.05	**54.2**	81.05	**61.45**	61.05	**75**	66	**67.65**
(postero-mediale)	±0.2	**±0.2**	±0.2	**±0.2**	±0.2	**±0.2**	±0.2	**±0.2**
	cm	**cm**	cm	**cm**	cm	**cm**	cm	**cm**

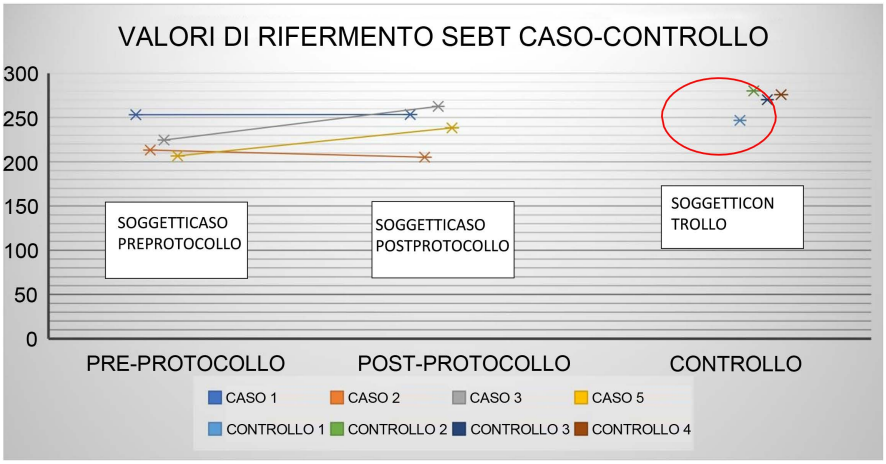

Figure 11. Comparison of SEBT reference values in case-control subjects.

Table 9. SH TEST.

SHTEST	*SOGGETTO1*		*SOGGETTO2*		*SOGGETTO3*		*SOGGETTO4*		*SOGGETTO5*	
	PRE	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*
FIGURE-8 TEST	14.87"	**11.18"**	17.26"	**15.17"**	X	**12.4"**	11.75"	**11.70"**	18.62"	**14.77"**
SIDEHOPTEST	5.08"	**4.59"**	10.98"	**5.79"**	5.46"	**4.6"**	5.02"	**4.94"**	10.45"	**10.83"**
UP-DOWNHOP	28.49"	**15.35"**	X	**25.19"**	22.64"	**12.22"**	18.02"	**10.02"**	24.7" (7rep)	**23.8" (10rep)**
SINGLEHOP	85.5 cm	**113.1 cm**	111.5 cm	**127 cm**	114.5 cm	**128.5 cm**	126.5 cm	**152 cm**	109 cm	**112 cm**

5. Conclusions

The objective of the study was to evaluate through the use of field tests considered most valid by scientific research (Docherty et. al. 2006; Grant L. Iverson et. al. 2013; Lauren C. Olmsted et. al. 2002; Hertel et. al. 2006), if there were improvements in terms of both static and dynamic stability in subjects suffering from chronic ankle instability, generated following an inversion sprain within the year or more than year. The subjects were then divided into two categories: subjects with CAI > 1 year and subjects with CAI ≤ 1 year. A protocol lasting 6 weeks was administered to both groups, trying to work on improving balance in single stance, improving static and dynamic stability, strengthening the gluteus medius and maximus (pelvis stabilizers) and strengthening of the intrinsic muscles of the foot. At the end of the protocol the subjects were all re-evaluated with the same field tests used previously and the data obtained were compared both with the pre-protocol data and with the data measured by the control subjects.

The results derived in the post-protocol tests are extremely positive in subjects with CAI ≤ 1 year, on the contrary, in subjects with CAI > 1 year the results obtained were null or even worse in the dynamic stability test (Star Excursion Balance Test), made exception for static stability tests. In conclusion, the results

obtained give hope for possible further improvements in the administration of protocols lasting longer than 6 weeks in both groups tested. As can also be seen from scientific research, and confirmed with this paper, subjects affected by CAI > 1 year need work protocols that are significantly longer and focus on improving static stability, but to a greater extent than dynamic stability, trying to reduce as much as possible also any muscular imbalances present in the upper structures, in particular of the pelvis. For CAI subjects ≤ 1 year, in accordance with scientific research, it is advisable to start with the process of functional re-education as soon as stabilization of the condition caused by the distortion is achieved, this will allow any relapses to be reduced to a minimum and, in particular, to avoid the onset of chronic ankle instability when not treated adequately.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Thompson, C., Schabrun, S., Romero, R., Bialocerkowski, A., Van Dieen, J. and Marshall, P. (2018) Factors Contributing to Chronic Ankle Instability: A Systematic Review and Meta-Analysis of Systematic Reviews. *Sports Medicine*, **48**, 189-205. https://doi.org/10.1007/s40279-017-0781-4

[2] Lin, C.I., Houtenbos, S., Lu, Y.H., Mayer, F. and Wippert, P.M. (2021) The Epidemiology of Chronic Ankle Instability with Perceived Ankle Instability—A Systematic Review. *Journal of Foot and Ankle Research*, **14**, 41. https://doi.org/10.1186/s13047-021-00480-w

[3] Kobayashi, T., Tanaka, M. and Shida, M. (2016) Intrinsic Risk Factors of Lateral Ankle Sprain: A Systematic Review and Meta-Analysis. *Sports Health*, **8**, 190-193. https://doi.org/10.1177/1941738115623775

[4] Doherty, C., Delahunt, E., Caulfield, B., Hertel, J., Ryan, J. and Bleakley, C. (2014) The Incidence and Prevalence of Ankle Sprain Injury: A Systematic Review and Meta-Analysis of Prospective Epidemiological Studies. *Sports Medicine*, **44**, 123-140. https://doi.org/10.1007/s40279-013-0102-5

[5] Gribble, P.A., Bleakley, C.M., Caulfield, B.M., Docherty, C., Fourchet, F. and Fong, D.T. (2016) Evidence Review for the 2016 International Ankle Consortium Consensus Statement on the Prevalence, Impact and Long-Term Consequences of Lateral Ankle Sprains. *British Journal of Sports Medicine*, **50**, 496-1505. https://doi.org/10.1136/bjsports-2016-096189

[6] Knowles, S.B., Marshall, S.W., Miller, T., Spicer, R., Bowling, J.M., Loomis, D., Millikan, R.W., Yang, J. and Mueller, F.O. (2007) Cost of Injuries from a Prospective Cohort Study of North Carolina High School Athletes. *Injury Prevention*, **13**, 416-421. https://doi.org/10.1136/ip.2006.014720

[7] Owoeye, O.B.A., Palacios-Derflingher, L.M. and Emery, C.A. (2018) Prevention of Ankle Sprain Injuries in Youth Soccer and Basketball: Effectiveness of a Neuromuscular Training Program and Examining Risk Factors. *Clinical Journal of Sport Medicine*, **28**, 325-331. https://doi.org/10.1097/JSM.0000000000000462

[8] Bicici, S., Karatas, N. and Baltaci, G. (2012) Effect of Athletic Taping and Kinesi-

otaping® on Measurements of Functional Performance in Basketball Players with Chronic Inversion Ankle Sprains. *International Journal of Sports Physical Therapy*, **7**, 154-166.

[9] Whalan, M., Lovell, R., McCunn, R. and Sampson, J.A. (2019) The Incidence and Burden of Time Loss Injury in Australian Men's Sub-Elite Football (Soccer): A Single Season Prospective Cohort Study. *Journal of Science and Medicine in Sport*, **2**, 42-47. https://doi.org/10.1016/j.jsams.2018.05.024

[10] Keogh, J.W.L. and Winwood, P.W. (2017) The Epidemiology of Injuries across the Weight-Training Sports. *Sports Medicine*, **47**, 479-501. https://doi.org/10.1007/s40279-016-0575-0

[11] Gabbett, T.J. (2000) Incidence, Site, and Nature of Injuries in Amateur Rugby League over Three Consecutive Seasons. *British Journal of Sports Medicine*, **34**, 98-103. https://doi.org/10.1136/bjsm.34.2.98

[12] Woods, C., Hawkins, R., Hulse, M. and Hodson, A. (2003) The Football Association Medical Research Programme: An Audit of Injuries in Professional Football: An Analysis of Ankle Sprains. *British Journal of Sports Medicine*, **37**, 233-288. https://doi.org/10.1136/bjsm.37.3.233

[13] Attenborough, A.S., Hiller, C.E., Smith, R.M., Stuelcken, M., Greene, A. and Sinclair, P.J. (2014) Chronic Ankle Instability in Sporting Populations. *Sports Medicine*, **44**, 1545-1556. https://doi.org/10.1007/s40279-014-0218-2

[14] Herzog, M.M., Kerr, Z.Y., Marshall, S.W. and Wikstrom, E.A. (2019) Epidemiology of Ankle Sprains and Chronic Ankle Instability. *Journal of Athletic Training*, **54**, 603-610. https://doi.org/10.4085/1062-6050-447-17

[15] De-La-Torre-Domingo, C., Alguacil-Diego, I.M., Molina-Rueda, F., Lopez-Roman, A. and Fernandez-Carnero, J. (2015) Effect of Kinesiology Tape on Measurements of Balance in Subjects with Chronic Ankle Instability: A Randomized Controlled Trial. *Archives of Physical Medicine and Rehabilitation*, **96**, 2169-2175. https://doi.org/10.1016/j.apmr.2015.06.022

[16] Hertel, J. and Corbett, R.O. (2019) An Updated Model of Chronic Ankle Instability. *Journal of Athletic Training*, **54**, 572-588. https://doi.org/10.4085/1062-6050-344-18

[17] Hiller, C.E., Kilbreath, S.L. and Refshauge, K.M. (2011) Chronic Ankle Instability: Evolution of the Model. *Journal of Athletic Training*, **46**, 133-141. https://doi.org/10.4085/1062-6050-46.2.133

[18] Kobayashi, T., Takabayashi, T., Kudo, S. and Edama, M. (2020) The Prevalence of Chronic Ankle Instability and Its Relationship to Foot Arch Characteristics in Female Collegiate Athletes. *Physical Therapy in Sport*, **46**, 162-168. https://doi.org/10.1016/j.ptsp.2020.09.002

[19] Fong, D.T., Hong, Y., Chan, L.K., Yung, P.S. and Chan, K.M. (2007) A Systematic Review on Ankle Injury and Ankle Sprain in Sports. *Sports Medicine*, **37**, 73-94. https://doi.org/10.2165/00007256-200737010-00006

[20] Almeida, S.A., Trone, D.W., Leone, D.M., Shaffer, R.A., Patheal, S.L. and Long, K. (1999) Gender Differences in Musculoskeletal Injury Rates: A Function of Symptom Reporting? *Medicine & Science in Sports & Exercise*, **31**, 1807-1812. https://doi.org/10.1097/00005768-199912000-00017

[21] Gribble, P.A., Hertel, J., Denegar, C.R. and Buckley, W.E. (2004) The Effects of Fatigue and Chronic Ankle Instability on Dynamic Postural Control. *Journal of Athletic Training*, **39**, 321-329.

[22] Cordova, M.L. (2005) Effects of Ankle Support on Lower-Extremity Functional Performance: A Meta-Analysis. *Medicine & Science in Sports & Exercise*, **37**,

635-641. https://doi.org/10.1249/01.MSS.0000159141.78989.9C

[23] Simon, J., Garcia, W. and Docherty, C.L. (2014) The Effect of Kinesio Tape on Force Sense in People with Functional Ankle Instability. *Clinical Journal of Sport Medicine*, **24**, 289-294. https://doi.org/10.1097/JSM.0000000000000030

[24] Witchalls, J., Blanch, P., Waddington, G. and Adams, R. (2012) Intrinsic Functional Deficits Associated with Increased Risk of Ankle Injuries: A Systematic Review with Meta-Analysis. *British Journal of Sports Medicine*, **46**, 515-523. https://doi.org/10.1136/bjsports-2011-090137

[25] Fraser, J.J., Koldenhoven, R.M., Jaffri, A.H., Park, J.S., Saliba, S.F., Hart, J.M. and Hertel, J. (2020) Foot Impairments Contribute to Functional Limitation in Individuals with Ankle Sprain and Chronic Ankle Instability. *Knee Surgery, Sports Traumatology, Arthroscopy*, **28**, 1600-1610. https://doi.org/10.1007/s00167-018-5028-x

[26] McCann, R.S., Crossett, I.D., Terada, M., Kosik, K.B., Bolding, B.A. and Gribble, P.A. (2017) Hip Strength and Star Excursion Balance Test Deficits of Patients with Chronic Ankle Instability. *Journal of Science and Medicine in Sport*, **20**, 992-996. https://doi.org/10.1016/j.jsams.2017.05.005

[27] McCann, R.S., Bolding, B.A., Terada, M., Kosik, K.B., Crossett, I.D. and Gribble, P.A. (2018) Isometric Hip Strength and Dynamic Stability of Individuals with Chronic Ankle Instability. *Journal of Athletic Training*, **53**, 672-678. https://doi.org/10.4085/1062-6050-238-17

[28] Song, K., Burcal, C.J., Hertel, J. and Wikstrom, E.A. (2016) Increased Visual Use in Chronic Ankle Instability: A Meta-Analysis. *Medicine & Science in Sports & Exercise*, **48**, 2046-2056. https://doi.org/10.1249/MSS.0000000000000992

[29] Burcal, C.J., Trier, A.Y. and Wikstrom, E.A. (2017) Balance Training versus Balance Training with STARS in Patients with Chronic Ankle Instability: A Randomized Controlled Trial. *Journal of Sport Rehabilitation*, **26**, 347-357. https://doi.org/10.1123/jsr.2016-0018

[30] Hoch, M.C., Staton, G.S., Medina McKeon, J.M., Mattacola, C.G. and McKeon, P.O. (2012) Dorsiflexion and Dynamic Postural Control Deficits Are Present in Those with Chronic Ankle Instability. *Journal of Science and Medicine in Sport*, **15**, 574-579. https://doi.org/10.1016/j.jsams.2012.02.009

[31] Martin, R.L., Davenport, T.E., Paulseth, S., Wukich, D.K. and Godges, J.J. (2013) Ankle Stability and Movement Coordination Impairments: Ankle Ligament Sprains. *Journal of Orthopaedic & Sports Physical Therapy*, **43**, A1-A40. https://doi.org/10.2519/jospt.2013.0305