Effects of a Neuromuscular Reeducation Program on the Postural Control in Gymnasts with Chronic Ankle Instability

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Key Words: Chronic Ankle Instability, Gymnastics, Neuromuscular Reeducation, Postural Sway, Postural Control, Time to Stabilization.

Abstract: Chronic ankle instability (CAI) is associated to the mechanical and/or functional instability of the ankle, being described as often residual change after sprain. Objective: To analyze the effects of a neuromuscular reeducation program for six weeks, in postural sway (PS) and time to stabilization (TS), in functional tests, in asymptomatic gymnasts and in gymnasts with CAI. Methods: The postural variation was evaluated – within sample of 24 gymnasts - 9 with CAI (experimental group) and 15 healthy ones (control group) through a pressure platform, before and after applying the exercise program. Results and Discussion: In the instability group it was observed an improvement in PS and TS in a single limb static stance with open and closed eyes, and after a landing of an anterior jump, medial and lateral side. In the control group a decrease of the PS in a single-limb static stance with eyes open and after the landing of a medial side jump was verified; improvement of the time to stabilization in the landing of lateral and medial side jump, after applying the exercise program. Conclusion: A neuromuscular reeducation program had a positive effect in the improvement of the postural control in gymnasts with or without CAI.

1 INTRODUCTION

Chronic ankle instability (CAI) has been described as the most common residual change of the ankle joint after injury (Caulfield et al., 2006). The ankle sprain is the most common injury in professional gymnasts (Kolt and Kirkby, 1999). According to Yeung et al., (1994) 40% to 70% of the individuals that suffered a ligament injury developed CAI.

CAI is one of the major residual dysfunction after an ankle sprain, being characterized as having a mechanic and/or functional component. Symptoms such as experiencing joint instability (*giving away*), pain and deficit in functional activities associated with recurrent injuries, establish a CAI scenario (Delahunt et al., 2010). This presents a multifactorial aetiology, where factors as joint laxity, muscular weakness and diminishing of sensibility of the proprioceptive mechanisms are related, originating a structural and biomechanical change in the joint, with a consequent deficit of the postural control when compared with healthy individuals (Denegar and Miller, 2002; Hubbard et al., 2006; Kavanagh, 1999; Willems et al., 2002).

According to Delahunt *et al.* (2010) CAI is a term used to describe individuals that portray mechanic and functional instability of the ankle, experience joint instability for at least one year after the injury and that have suffered from at least two sprains of average/mild severity in the last two to three years.

About 45% of all ankle injuries occur in landing after a jump (McKay et al., 2001). Individuals with functional instability (FI) of the ankle present changes in the standard movement before impact with the soil in the reception of a single-limb jump when compared with healthy individuals (Caulfield and Garrett, 2002). These differences can occur because of changes in the control of the standard movement due to earlier injury (Caulfield and Garrett, 2004) or resulting dysfunctions. Single Leg Jump Landing (SLJL) testing has been frequently used to assess the CAI effects in postural sway stability (Brown et al., 2004; Wikstrom et al., 2005). CAI has been related with an increase in the stabilization time (ST) in the frontal and sagital plans and several studies support this as the responsible factor for the changes and deficits that

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occur in the jump landing (Brown et al., 2004; Ross et al., 2005). Brown and Mynark (2007) show that individuals with CAI take more time stabilizing after a dynamic activity than the non-injured control group.

Postural control is usually calculated by postural sway, through the measure of the distance and amplitude of the CoP´s displacement (Mattacola and Dwyer, 2002). A decrease of the length and area of the CoP´s displacement and a reduction of its velocity of excursion indicate an improvement of the efficiency of the postural control (Sefton et al., 2009).

Several studies refer neuromuscular reeducation, namely through platforms or unstable surface, presenting positive results in the reintegration of the postural control mechanisms (Mattalcola and Dwyer, 2002; Baltaci and Kohl, 2003; Wilkerson and Nitz, 1994).

The main goal of the present study is to analyze the effects of a neuromuscular reeducation program adapted to gymnastics, in postural sway and the time to stabilization, in some dynamics or physical tests in asymptomatic gymnasts and in gymnasts with CAI.

2 METHODS

This is a quasi-experimental study, with a framework of research of the pre-testing – post-testing type with non-equivalent work group: there was no random element distribution that belonged to the two groups – the group of unstable subjects and the group of healthy subjects.

The study sample is composed by 24 subjects, 9 (37,5%) males and 15 (62,5%) females; aged between 15 and 24 years old (Average = 17,67 ± 2,85 years). It was selected by convenience out of a population of gymnasts from Portugal's Gymnastics Federation and according to the following inclusion criteria:

<u>Experimental Group (EG): Inclusion Criteria</u>

- History of occurrence of, at least two ankle sprain injury (grade II), from which resulted ligament injuries with an edema/ecchymosis, pain, temporary loss of function and that have occurred in the last three years but more than three months ago.
- CAI history with symptoms of lack of confidence in the joint and/or residual pain, diminished function and momentary loss of control, even if in minor episodes.

<u>Experimental Group (EG): Exclusion Criteria</u>

- Ankle joint's average gravity sprain in study in the last three months (excludes acute and sub-acute situations).
- History of other injuries in the lower limbs (except the ankle joint) in the six months before the data collection and/or not totally recovered.
- Neurologic symptoms or troubles.
- Vestibular and visual disorders that affect the balance.
- Previous surgery history and/or lower limb fractures.

<u>Control Group (CG) – Inclusion Criteria</u>

With no changes or previous injuries from the musculoskeletal and neurologic nature in any of the lower limbs. Asymptomatic gymnasts with no functional or sportive limitations and in full gymnastics activity.

The subjects were properly informed about the study's objectives, about all the procedures and were only included in the sample after their formal consent. Each subject also fulfilled an informed permission form. In the cases when gymnasts were underage, the form needed to be fulfilled by a tutor.

Two groups were created, the Experimental Group (EG) – subjects with chronic ankle instability (n=9) and the Control Group (CG) – healthy subjects (n=15). The healthy group was randomly divided in two sub-groups, a group of healthy individuals that did an exercise program (n=7) – Control Group with Exercises (CG1); and a group of healthy individuals that was not subjected to the exercise program (n=8) – Control Group without Exercises (CG2). All the EG gymnasts were subjected to an exercise program.

The length and displacement area of the CoP were measured – dependable variables, during six seconds in the maintenance of the single limb static stance (open and closed eyes) and after a jump's landing (anterior, lateral, medial). Moreover, the first six seconds measured for each of these motor tasks were analyzed in three distinct timeframes – in the first two seconds (T1), from the second to the forth seconds (T2); and from the forth to the sixth seconds (T3). Having the concept of stabilization time used by Ross e al. (2005) as basis and because there is no consensus on the existing studies, about its definition, we have approached the stabilization time through the changes and postural oscillation parameters' evolution – area and length, in a determined timeframe in comparison to other (ex. T1_T2, which corresponds to the different values obtained in the Cop in the timeframe T2 in comparison to T1).

A multi-station exercise plan was developed (see Appendix). This frames a set of seven functional strengthening and neuromuscular re-education exercises, to control the dynamic balance, in a series of motor tasks and functional activities related with gymnastic tasks, mainly the single limb standing stance on unstable surfaces and a jump's landing, in order to improve the *feedback* and *feedforward* mechanisms. Research suggests (Konradsen et al., 1997; Holmes and Delahunt, 2009) are important and essential in the task's motor control and injury prevention. The created exercise plan was performed with a total duration of six weeks, in a frequency of three times per week and an average duration of 15/20 minutes per session.

3 MEASUREMENT TOOLS

In this study, the postural oscillation was measured through a 0,5m *Footscan*® pressure platform to measure the length (mm^2) and area (cm^2) covered by the CoP´s displacement to the different study tasks. The individuals studied were also subjected to a characterization and evaluation in the Foot and Ankle Outcome Score (FAOS), aimed at identifying the existing differences about pain, other symptoms, daily life functions, sports and leisure functions and quality of life between the subjects.

4 PROCEDURES

All the subjects were informed not to take coffee, alcoholic drinks and medication 24 hours prior to the evaluation, as well as trying to sleep eight hours the night before.

According to the design of this study's research, there were performed two moments of evaluation, one before the application of the multi-station exercise program – Baseline (O1), and another, six weeks after its application (O2). The several tasks were evaluated on the same day, choice of the order of tasks done randomly, and for each of them there were made three measurements. The average of the three results was used throughout the treatment and interpretation of the results. In case the subject doesn't complete one of the measurements with success in time, by unbalance and loss of test position, the test will be repeated as many times as necessary until three valid measures are obtained for each test. In the evaluated dynamic activities, each subject had the opportunity to perform the required test once, before its effective measure.

To measure the postural oscillation of a jump it was determined a priori the value of the maximum vertical impulsion for each gymnast. After determining this value, the jump tasks were performed at least at 50% of the maximum vertical impulsion, this value being marked in the space with a rubber band and serving as a reference for the gymnast during the jump from the floor to the platform.

5 DATA ANALYSIS

After data collection and process was performed, the statistical treatment was of them was given through a SPSS for Window V.19.0 statistic treatment software. A statistic inference was used for the data treatment. Due to the small number of the sample, the collected data was subjected to a statistic treatment using non parametrical tests. For intragroup evaluation tests were used for grouped samples and for intergroup evaluation, tests for independent samples - Kruskal-Wallis, to a level of significance of $p \leq 0,05$.

6 RESULTS

In Tables 1 and 2 are presented the results of the comparison between the intragroup and the intergroup concerning the values obtained in O1 and O2 in CoP´s length and displacement area in the three timeframes analyzed – from zero to two seconds; from two to four seconds and from four to six seconds, in maintaining the balance and after the jump's landing. The results presented will be just the ones with statistical significance ($p \leq 0,05$).

In the experimental group we saw statistical significant improvements in all the tasks being studied concerning the CoP´s displacement and its stabilization time. The control group that did the neuromuscular reeducation program (GC1) showed significant statistic results in the displacement of the single limb static stance with the eyes open and in the length and area of the CoP's displacement after the landing of a medial jump. When it comes to the stabilization time, GC1 showed more improvement in the medial and lateral jumps' landing. For the control group that didn't performed the neuromuscular reeducation program (GC2), we saw significant statistical changes in the CoP's single limb static stance with eyes closed and after an

Table 1: Results obtained from comparasion of the O1´s comparison with O2 CoP´s displacement length and area, in the different tasks analyzed, in the three groups.

TASKS	EG	CG 1	CG 2
SLSS_YO	A T3 (p=0,020)	A T2 (p=0,055)	----
SLSS_YC	L T3 (p=0,037)	----	L + A T1 (p=0,02; p=0,008)
AJ	A T1 (p=0,037)	----	L + A T1 (p=0,027; p=0,055)
LJ	L T1 (p=0,065) L + A T3 (p=0,008; p=0,002)	----	----
MJ	L + A T1 (p=0,037; p=0,027) L + A T3 (p=0,04; p=0,20)	L + A T1 (p=0,08; p=0,08) A T3 (p=0,023)	----

SLSS_YO – single limb static stance with eyes open; SLSS_YC – single limb static stance with eyes closed; AJ – anterior jump; LJ – lateral jump; MJ – medial jump; EG – experimental group; CG1 – control group with exercises; CG2 – control group without exercises; A - the area of the CoP´s displacement; L – the length of the CoP´s displacement; T1 – 0 to 2 sec; T2 – from 2 to 4 sec; T3 – from 4 to 6 sec.

significant statistical changes in the CoP's single limb static stance with eyes closed and after an anterior jump's landing. Still in this group, we verified improvement in the stabilization time after an anterior jump.

By analyzing chart 1 we may verify that there was a slight improvement in the score obtained by the FAOS scale, in the EG Experimental Group, after the exercise plan finished, at the level of the other symptoms, sports and leisure functions and quality of life connect to the foot and ankle. We didn´t verify any differences by the FAOS scale, when comparing observation 2 to 1, to the control group with exercises (GC1).

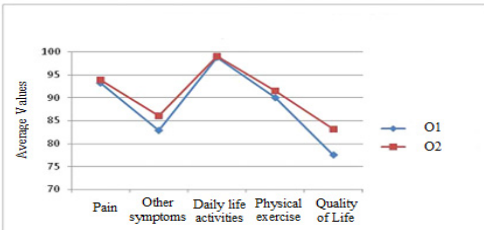
7 DISCUSSION

SLJL tests have often been used to evaluate the effects of FAI on the dynamic postural stability of the ankle (Brown et al., 2004; Wikstrom et al., 2005), and its improvement through exercise programs in patients with CAI (Ross et al., 2005). Several studies (Powers et al., 2004; Sefton et al., 2011) report that statistically significant results in improving postural sway on single leg standing, through the assessment of static balance, following the application of an exercise program were not found. However, changes were found through dynamic assessment (Sefton et al., 2011). Based on these data and considering the fact that at the gym, most ankle injuries occur on landings, it seemed useful to assess the postural sway and stabilization time dynamically on landings.

Table 2: Results obtained from comparison of the O1´s comparison with O2 time of stabilization, in the different tasks analyzed, in the three groups.

TASKS	EG	CG 1	CG 2
SLSS_YO	L + A T2_T3 (p=0,037; p=027)	----	----
SLSS_YC	L T1_T3 (p=0,025)	----	----
AJ	A T1_T2 (p=0,037) A T1_T3 (p=0,037)	----	L T1_T2 (p=0,008)
LJ	A T2_T3 (p=0,006)	A T1_T2 (p=0,055)	----
MJ	A T2_T3 (p=0,027) A T1_T3 (p=0,020)	A T1_T2 (p=0,055)	----

SLSS_YO – single limb static stance with eyes open; SLSS_YC – single limb static stance with eyes closed; AJ – anterior jump; LJ – lateral jump; MJ – medial jump; EG – experimental group; CG1 – control group 1; CG2 – control group 2; A - the area of the CoP´s displacement; L – the length of the CoP´s displacement; T1 – 0 to 2 sec; T2 – from 2 to 4 sec; T3 – from 4 to 6 sec; T1_T2 difference of CoP´s values obtained in the interval T1 in comparison to T2; T2_T3 difference of COP´s values obtained in the interval T2 in comparison to T13; T1_T2 difference of CoP´s values obtained in the interval T1 in comparison to T3.



Graphic 1: Values obtained through the FAOS to the EG in O1 and O2.

A study by Fellander-Tsai and Wredmark (1995) found that most injuries in competitive gymnasts occurred on landings. The gymnast's ability to land a jump or technical element skill, often on different surfaces, and prepare for immediate take-off for another skill, requires a high motor and postural control of the gymnast. In case of CAI, deficits in the neuromuscular mechanisms, inherent to postural control, can lead to an increased risk of recurrent injury. The specificity of the sport, with the more emphasis on feedforward mechanisms, rather than feedback mechanisms in postural control (Konradsen et al., 1997; Holmes and Delahunt, 2009), led to the creation of an exercise program with special focus on skills development for motor pre-programming where the landing of jumps was given special emphasis. According Delahunt (2007), training exercises performed on unstable surfaces for the training correct technique of landing, especially on single leg, will emphasize the synergistic muscle activity pre-programmed by feedforward mechanisms in subjects with FAI. Thus, the study also included in the program exercises that promote specific mechanisms of postural control feedback like single leg balance, with the need of constant posture adjustments and where the reflex activity plays a key role. Mynark and Brown (2007) demonstrated in their study that individuals with CAI take longer to stabilize after a dynamic activity than the control group of subjects with no previous injuries. This increase in stabilizing time can lead to an increased recurrence of ankle injuries due to the inability to properly execute the landing after a jump (Ross et al., 2005). It at least it suggests that the posture control mechanisms are less efficient. Based on these studies, our program also included exercises that develop balance and motor control in plyometric tasks (different types of jumps in different conditions and landing directions). The program had six weeks duration with a weekly frequency of three times a week. The determination of the time set for its use is in line with previous studies. Hale et al., (2007) in their study demonstrated positive results in improving posture control with an exercise program for four weeks five times per week. Bernier and Perrin (1998); Rosenbaum and Elis (2001); Burden and Clark (2005), Powers et al., (2004); Docherty et al., (1998); Sefton et al., (2011) found positive results with an experimental six weeks protocol, three times a week.

Within the group of gymnasts with CAI - experimental group - there was a significant improvement in all the tasks in study, which reinforces the effectiveness of the exercise program in improving postural control and joint stability. These results are in line with other studies, where the application of an exercise program with proprioceptive exercises, particularly balance training on unstable surfaces, showed positive results in the reprogramming of postural control mechanisms in subjects with CAI (Mattacola and Dwyer, 2002; Baltaci and Kohl, 2003; Wilkerson and Nitz, 1994). Bernier and Perin (1998) had statistically significant results with CoP´s displacement on single leg balance with eyes closed, in the CAI group, after application of an exercise program for six weeks.

Gymnastics skills with postures in single leg support are frequent (eg. static balance skills like scales, stability posture after a jump for a relatively long period). The results achieved in improving single leg postural sway demonstrate the positive effect of training, with the exercise program performed. This aspect determines improved stability, and thereby improving the performance of the gymnasts.

For more dynamic activities, there were improvements in postural sway and stabilization time on landing, to the front and to the medial and lateral sides, in subjects with CAI. These data reveal an improvement of dynamic joint stability, both anteroposterior and mediolateral stability after completion of the exercise program. According Sefton et al. (2009), a decrease in CoP´s length and area displacement and a reduction of its velocity indicate an improvement in postural control. In their study, these authors reported an improvement in the dynamic balance in the anteroposterior, medial and posteromedial directions, after the application of a proprioceptive exercise training program for six weeks in subjects with CAI.

In the control group of healthy subjects, who also performed the exercise program (GC1), there were statistically significant improvements in single leg balance with eyes open, and on the landing of an medial lateral jump. These results demonstrate a positive effect of the exercise plan, improving the dynamic stability in healthy subjects. The improvement in postural sway and stabilization time in healthy subjects reported in this study, suggests a possible implementation of this type of training for injury prevention of the ankle and performance improvement in gymnasts.

In a study of this nature, the kinematics and EMG analysis could give more information. This could be considered one of the limitations to this study. Another methodological limitation of this study relates to the size of the sample. However, the value of the sample under study (n = 24), while somewhat lower than in other studies appear to be similar to the average sample used in some similar studies carried out previously.

However, we consider our options are in line with the goal set for the scope of this research. The options seem appropriate, taking into account the specific context of the sample under study and specificity of the sport.

Despite these limitations, the objectives set for this study were achieved: to assess the effects of a neuromuscular program in competitive gymnasts with CAI, thus making a contribution to practice evidence-based physiotherapy.

8 CONCLUSIONS

The application of a six weeks neuromuscular program seems to have positive effects in improving postural control in gymnasts with and without CAI. Results suggest an improvement of postural control on the sample subjects, stressing the relevance of the use of rehabilitation programs to improve dynamic and functional stability, in order to reduce the risk of recurrence of injury and further improvement of athletic performance.

Although many studies have been developed in this area, we emphasize the importance of assessing dynamic postural control, where the feedforward mechanisms are especially important, as well as the intervention with exercise programs that improve the development of these neuromotor mechanisms.

REFERENCES

Baltaci, G. & Kohl, H. W. (2003). Does proprioceptive training during knee and ankle rehabilitation improve outcome? *Physical Therapy Reviews*, 8, 5–16.

Bernier, J. N. & Perrin, D. H. (1998) Effect of coordination training on proprioception of the functionally unstable ankle. *The Journal of Orthopedic and Sports Physical Therapy*, 27 (4), 264-75.

Brown, N. & Mynark, R. (2007) Balance deficits in recreational athletes with chronic ankle instability. *Journal of Athletic Training*, Jul-Sep: 42(3), 367-73.

Brown *et al*. (2004) Assessing functional ankle instability with joint position sense, time to stabilization and electromyography. *Journal of Sport Rehabilitation*. 13(2), 122-134.

Caulfield, B., Delahunt, E. & Kenneth, M. (2006) Altered neuromuscular control and ankle joint kinematics during walking in subjects with functional instability of the ankle joint. *American Journal of Sports Medicine*, 34 (12), 1970-77.

Caulfield, B. & Garrett, M. (2004) Changes in ground reaction force during jump landing in subjects with functional instability of the ankle joint. *Clinical Biomechanics*, 19, 617-621.

Caulfield, B. M. & Garrett, M. (2002) Functional instability of the ankle: differences in patterns of ankle and knee movement prior to and post landing in a single leg jump. *International Journal of Sports Medicine*, 23, 64-68.

Clark V. M., Burden A. M. (2005) A 4-week wobble board exercise program improved muscle onset latency and perceived stability in individuals with a functionally instable ankle. *Phys Therapy Sport,* 6, 181-7.

Delahunt, E. *et al.* (2010) Inclusion Criteria when Investigating Insufficiencies in Chronic Ankle Instability. *Medicine & Science in Sports & Exercise*, Nov: 42(11), 2106-2121.

Delahunt, E. (2007a) Neuromuscular contributions to functional instability of the ankle. *Journal of Bodywork and Movement Therapies*, 11, 203-213.

Denegar, C. R. & Miller, S. J. (2002) Can chronic ankle instability be prevented? Rethinking management of lateral ankle sprains. *Journal of Athletic Training*, 37, 430-5.

Docherty, C. L., Moore, J. H. & Arnold, B. L. (1998) Effects of strength training on strength development and joint position sense in functionally unstable ankles. *Journal of Athletic Training*, 33, 310-14.

Eils, E. & Rosenbaum, D. (2001) A multi-station proprioceptive exercise program in patients with ankle instability. *Medicine & Science Sports & Exercise,* 33 (12), 1991-8.

Fellander-Tsai, L. & Wredmark, T. (1995) Injury incidence and cause in elite gymnasts. *Arch Orthop Trauma Surg. 114 (6)*, 344-346.

Hale, S. A., Hertel, J. & Olmsted-Kramer, L. C. (2007) The effect of a 4-week comprehensive rehabilitation program on postural control and lower extremity function in individuals with chronic ankle instability. *Journal Orthopedic & Sports Physical Therapy*, 37 (6), 303-11.

Holmes, A. & Delahunt, A. (2009) Treatment of common deficits associated with chronic ankle instability. *Sports Medicine*, 39 (3), 207-224.

Hubbard, T. J., Hertel, J. & Sherbondy, P. (2006) Fibular position in individuals with self-reported chronic ankle instability. *Journal Orthopedic & Sports Physical Therapy*, 36, 3-9.

Kavanagh, J. (1999) Is there a positional fault at the inferior tibiofibular joint in patients with acute or chronic ankle sprains compared to normal? *Manual Therapy*, 4, 19-24.

Kolt, G., Kikby, R. (1999). Injury in Australian female competitive gymnasts: a psychological perspective. Australian Physiotherapy, 42 (2), 121-126.

Konradsen, L., Voight, M. & Hojsgaard, C. (1997) Ankle inversion injuries. The role of the dynamic defense.mechanism. American Journal of Sports Medicine, 25, 54-58.

Mattacola, C.G. & Dwyer, M.K. (2002). Rehabilitation of the ankle after acute sprain or chronic instability. Journal of Athletic Training. 37(4):413–429.

McKay, G. D., Goldie P. A., Payne W. R. & Oaks B. W. (2001) Ankle injuries in basketball: injury rate and risk factors. *British Journal of Sports Medicine*, 35, 103-108.

Powers, M. et al (2004) Six weeks of strength and proprioception training does not affect muscle fatigue and static balance in functional ankle instability. *Journal of Sport Rehabilitation,* 1(3), 201-227.

Ross, S. E. & Guskiewicz, K. M. (2006) Effect of coordination training with and without stochastic resonance stimulation on dynamic postural stability of subjects with functional ankle instability and subjects with stable ankles. *Clinical Journal of Sports Medicine* 16, 323–328.

Ross, S. E., Guskiewicz, K. M. & Yu B. (2005) Single leg jump-landing stabilization times in subjects with functionally unstable ankles. *Journal of Athletic Training*, 40, 298-304.

Sefton, J. M. *et al* (2011) Six weeks of balance training improves sensorimotor function in individuals with chronic ankle instability. *Journal of Orthopedic & Sports Physical Therapy*, 41 (2), 81-89.

Sefton, J. M., *et al*. (2009). Sensorimotor function as a predictor of chronic ankle instability. *Clinical Biomechanics*. 24, 451–458.

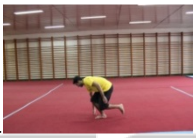
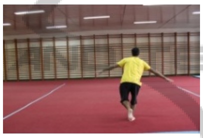
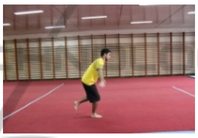
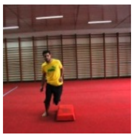
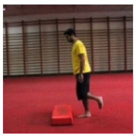
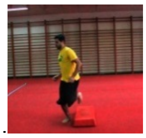
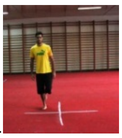
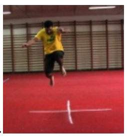
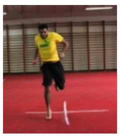
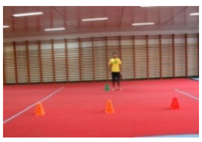
Wilkerson, G. B. & Nitz, A. J. (1994) Dynamic ankle stability: mechanical and neuromuscular interrelationships. *Journal of Sports Rehabilitation*, 3, 43-57.

Wikstrom, L. A. *et al*. (2005) Detection of dynamic stability deficits in participants with functional ankle instability. *Medicine & Science Sports & Exercise*. 37(2), 169-175.

Willems, T., Witvrouw, E. & Verstuyft, J., et al (2002) Proprioception and muscle strength in subjects with a history of ankle sprains and chronic instability. *Journal of Athletic Training*, 37, 487-93.

Yeung, M., Chan, K., So, C. & Yuan, W. (1994) An epidemiological survey on ankle sprain. *British Journal of Sports Medicine*, 28, 112-116.

APPENDIX

Multi-Station Exercise Program	Sets x Repetitions / Time between Sets
Exercise 1 – Rotation of the body in a single limb stance 1.  2. 	1x 1 min – on the floor 1x1min – on the mat (medium density) 1x1min – on the Trampoline Time between Sets - from 20 to 60s 6th week – with eyes closed
Exercise 2 – Sequence in a single limb stance 1.  2.  3. 	2x 4 sequences 1st week – on the floor 2nd week - on the mat (medium density) From 3rd to 6th week – on the trampoline Time between Sets - from 20 to 60s
Exercise 3 - ¼ jump, stabilizing the landing 1.  2.  3. 	2 x 12 jumps 1st and 2nd week – on the floor 3rd and 4th week - on the mat (medium density) 5th and 6th week - on the trampoline Time between Sets - from 20 to 60s
Exercise 4 – Lateral jumps 1.  2.  3. 	2x 10 jumps Time between Sets - from 30 to 60s
Exercise 5 – Antero-posterior jumps 1.  2.  3. 	2x 10 jumps Time between Sets - from 30 to 60s
Exercise 6 - Plyometric trainning with multidireccional jumps 1.  2.  3. 	1x 2 sequences around 1x 2 sequences in 8 Time between Sets - from 30 to 60s
Exercise 7 – Running with direction changing 1.  2. 	1x 1 min