Proprioceptive Re-Education and Reathletization in Outcomes of Ankle Dislocation

Reeducación propioceptiva y reatletización en los resultados de la luxación de tobillo

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Abstract:

Ankle instability is a condition where the patient experiences a sensation of inability to bear weight and frequent episodes of ankle giving way during walking or running. This condition is primarily due to the rupture of ankle ligaments, most commonly the lateral ligaments, which lose their ability to stabilize the bones of the ankle, resulting in impaired function during movement (Vega J. et al., 2018). Chronic ankle instability can be attributed to congenital ligament laxity, but it is more often the consequence of one or more inadequately treated or underestimated sprains (Menna M., 2020). This study focused on physically active individuals and athletes from various disciplines and age groups, as chronic ankle instability has been found to have a significant incidence in both sports-related and non-sports-related injuries. Although limited by the sample size, the results of this study provide a starting point for future research, where an expanded sample and the inclusion of a control group receiving no treatment could be considered. In conclusion, based on the present findings, an integrated approach to patient care is recommended, involving not only physiotherapy with the use of SynergyMatt but also a customized motor activity program tailored to the patient's specific needs.

Keywords:

Sport, physical education, reathletization.

Resumen:

La inestabilidad del tobillo es una condición en la que el paciente experimenta una sensación de incapacidad para soportar peso y episodios frecuentes de inestabilidad del tobillo durante la caminata o la carrera. Esta condición se debe principalmente a la rotura de los ligamentos del tobillo, siendo los ligamentos laterales los más comúnmente afectados, los cuales pierden su capacidad para estabilizar los huesos del tobillo, lo que resulta en una función deteriorada durante el movimiento (Vega et al., 2018). La inestabilidad crónica del tobillo puede atribuirse a una laxitud ligamentosa congénita, pero con mayor frecuencia es consecuencia de esguinces mal tratados o subestimados (Menna, 2020). Este estudio se centró en individuos físicamente activos y atletas de diversas disciplinas y grupos de edad, ya que se ha encontrado que la inestabilidad crónica del tobillo tiene una incidencia significativa tanto en lesiones deportivas como no deportivas. Aunque limitado por el tamaño de la muestra, los resultados de este estudio ofrecen un punto de partida para futuras investigaciones, donde se podría considerar una muestra más amplia y la inclusión de un grupo control que no reciba tratamiento. En conclusión, con base en los hallazgos presentes, se recomienda un enfoque integrado en el cuidado del paciente, que implique no solo fisioterapia con el uso de SynergyMatt, sino también un programa de actividad motora personalizado adaptado a las necesidades específicas del paciente.

Palabras claves:

Deporte, educación física, reatlización.

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Introduction

Ankle instability is a condition in which the individual experiences a sensation of inability to bear weight and frequent episodes of ankle giving way during walking or running. As described by Vega J. et al. (2018), this condition results from injury to the ankle ligaments, most commonly the lateral ligaments, which fail to stabilize the bones of the ankle, leading to impaired function during movement.

Hiller C.E. et al. (2011), following ICF guidelines, defined chronic ankle instability as characterized by increased ligament laxity and proprioceptive deficits, leading to limitations in daily activities and restrictions in sports participation and work-related tasks.

For the analysis of this pathology, the Human Tecar Synergy Matt platforms were employed. These platforms simulate various surfaces with different levels of instability using elastic, load-reducing materials, making them ideal for joint mobilization with reduced load (Herring J.A., 2014). The use of these platforms is crucial for proprioceptive sensitivity, an advanced mechanism aimed at providing the central nervous system with precise, real-time information regarding the biomechanical parameters of movement, such as speed, force, direction, and acceleration, as well as physiological and biological states in muscles, tendons, and joints following movement (Pagella F. et al., 2018).

The Human Tecar Synergistic Healthcare Methodology and Synergy Matt represents an optimal approach for functional recovery, rehabilitation, postural improvement, and proprioceptive rebalancing. It is also used as an integration into specific training programs across various sports disciplines.

Photo 1, Synergy Mat, exercises on proprioceptive surface

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The platforms used in this rehabilitation protocol include various types:

- Medium Density Synergy Mat (Wellness): Features flat, medium-density elastic response spurs, ideal for movements with reduced joint loading (Harris E.J. et al., 2004).
- High Synergy Mat (Performance): An uneven surface that simulates sandy terrain, stimulating microcirculation and the foot's mechanoreceptors, activating stabilizing muscles. It is recommended for professional and high-level sports (Bellomo R.G. et al., 2012).
- Stones Synergy Mat: Mats of varying densities that simulate a rocky and uneven surface, promoting activation of the mechanoreceptors in the sole of the foot.
- Dunes Synergy Mat: Stimulates microcirculation and targets mechanoreceptors in the sole. The irregular surface, combined with the resistance provided by the "sand," enhances stabilizing muscle work.
- Synergy Mat Pillow: Elastic response cubes of various sizes that allow for step and aerobic exercises, contributing to higher caloric expenditure.
- Needle: A rigid platform with a medium elastic push-back base, equipped with a rubber needle mat, ideal for plantar micromassage, particularly suited for neurological patients (Harris E.J. et al., 2004).

Photo 2, Human Tecar Synergy Mat

This type of training is designed for individuals recovering function after surgery or trauma, as it generates proprioceptive activity without sudden or rapid movements. It can also be applied to children and adolescents. For the former, it promotes varied and targeted work on the plantar musculature, enhancing gait, while for the latter, it supports the improvement of balance and the maintenance of correct posture and gait biomechanics.

Athletes, whether professional or amateur, can use it to specifically train proprioception, linking it to the athletic or technical gestures of their sport. Additionally, it can benefit overweight/obese individuals and those with phlebolymphatic disorders, as the elastic resistance of the platforms reduces mechanical and joint load during movement, facilitating greater energy expenditure. In cases of phlebitis, it also promotes better venous return, helping to alleviate circulation problems.

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According to the literature, ankle proprioception is closely linked to balance control, and compromised ankle proprioception after an injury negatively affects balance (Han J. et al., 2015). Han J. et al. (2015) found that proprioceptive ankle training, including stretching, mobilization, strengthening, and balance board exercises, improved static and dynamic balance index scores in healthy individuals. Similarly, Akre A. et al. (2014) compared the effectiveness of muscle strengthening and proprioceptive training programs on dynamic balance in athletes with chronic ankle instability (CAI), demonstrating that both are essential for improving balance.

Lee A.J. et al. (2008) examined the effects of 12 weeks of biomechanical platform training on postural stability and ankle proprioception in individuals with unilateral functional instability, concluding that this training improved postural stability and tibio-tarsal proprioception.

Proprioceptive training was compared to lower limb strength training in vertical jump performance. The results indicated that, in the short term, one week of lower limb strength and proprioceptive training was not sufficient to produce statistically significant improvements in vertical jump performance (Adam S. et al., 2018). Similarly, Zech et al. (2010) found that at least 3 weeks of balance and proprioception training are required to achieve clear improvements in postural and neuromuscular control.

Proprioceptive training has been shown to improve proprioceptive function by up to 20%, with effect sizes ranging from medium to large (<0.5). Proprioceptive training typically involves somatosensory stimulation using a combination of passive and active movement, with and without exteroceptive feedback (effect size >0.8) (Eils E. et al., 2001). Overall, proprioceptive training is effective in enhancing proprioceptive function by utilizing somatosensory and tactile cues to achieve the ultimate goal of restoring sensory and/or sensorimotor function (Ashton-Miller J.A. et al., 2001).

Materials and Methods

The study group consisted of 34 participants, aged between 22 and 32 years, randomized into two groups: an experimental group (n=17) and a control group (n=17). All participants received either the treatment or control conditions according to their group assignment.

The experimental group (n=17) underwent treatment with the Synergy Mat, while the control group (n=17) was subjected to adapted physical activity (AFA) only.

Both groups underwent a cycle of 12 sessions, with the experimental group receiving Synergy Mat therapy and the control group performing adapted physical activity (AFA), at a frequency of 2 sessions per week over a 6-week period.

The Synergy Mat refers to a revolutionary method that involves the use of surfaces with various shapes and materials designed for training, rehabilitation, and re-education of the muscular system, posture, and proprioceptive rebalancing. This is achieved through barefoot stimulation without joint loading, while simultaneously increasing energy and calorie expenditure by raising heart rate.

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Specifically, the Human Tecar Synergy Mat Medium Density was used, featuring flat elastic response spurs of medium density, ideal for movements with minimal joint load.

The Synergy Mat protocol included:

- Maintaining orthostatic, bipodal, and monopodal positions.
- Walking forward and backward on various Synergy Mats (medium, stones, dunes).
- Heel walking (rearfoot) forward and backward.
- Forefoot walking forward and backward, focusing on balance.
- Rolling foot walk: heel-plantar ball-toe-push off.
- Walking in ankle pronation and supination.
- Quarter squats, both monopodal and bipodal, with eyes open or closed.
- Step-ups on a soft pillow (multypillow) with eyes open and closed.

Photo 3, maintenance of orthostatic position on Synergy Mat

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Photo 4, monopodal balance in orthostatic position on Synergy Mat

Photo 5, forward walking on Synergy Mat

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Photo 6, foot pronation-supination on Synergy Mat

All exercises specified in the protocol were performed on various types of platforms (dunes, stones, medium density, high synergy, and mat pillow) to provide maximal proprioceptive stimulation, with exercise difficulty increased as stability and accuracy improved, such as by removing visual sensory input (Fantin V., 2021/2022).

For the control group undergoing adapted physical activity (AFA), exercises included stretching, mobilization, and strengthening using elastic bands and proprioceptive boards. Notable exercises included dorsiflexion and plantarflexion of the ankle with an elastic band (towel stretch), both actively and passively, and on a rectangular proprioceptive board, Balance Pad, and round Balance Board in a monopodal stance, initially unloaded and then progressively loaded.

Similarly, pronation-supination exercises of the tibio-tarsal joint were performed with an elastic band, both actively and passively, with load and unloading using the same platforms and boards. These exercises aimed to improve the range of motion of the joint, optimize coordination, and achieve proper body perception in static and dynamic balance.

Finally, for muscle strengthening, lunges and squats were performed on the Balance Board with an isometric variation to strengthen the lower limb muscles, including the quadriceps, gluteus maximus to reduce ankle overload, hamstrings, adductors, gastrocnemius, and soleus.The study included subjects aged between 22 and 30 years who reported an ankle sprain of grade 1 or 2. Subjects with grade 1 sprains exhibited edema and bruising in the tibio-tarsal joint with pain but no functional deficits.

Those with grade 2 sprains, in addition to edema, experienced mild functional deficits and pain under load, with partial injury to one or more ligaments.

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Subjects with multiple injuries, other conditions that limited mobility, or ankle trauma requiring joint immobilization were excluded from the study. Additionally, subjects who were unable to follow or adapt to the protocol were not considered. The control group underwent a cycle of 12 sessions, with a frequency of 2 times a week for 2 weeks. The results of this study, although limited by the sample size, provide a starting point for future research,

Results

The symmetry and kurtosis analysis tests, along with the Kolmogorov-Smirnov normality test, confirm the normal distribution of the data ($p<.0001$). Therefore, parametric tests were used to investigate differences between groups and the efficacy of the experimental and motor protocols.

The variables analyzed refer to three measurements:

Anterior Drawer Test (1 item)

Foot and Ankle Disability Index (8 items): a. Running b. Jumping c. Landing d. Ability to squat and stop quickly e. Lateral movements f. Low-impact activities g. Ability to perform activities with normal technique h. Ability to participate in sports activities

SF36 Questionnaire (36 items – 8 variables): a. Physical functioning b. Limitations due to physical health c. Limitations due to emotional problems d. Energy and fatigue e. Emotional well-being f. Social activities g. Pain h. Perception of general health.

Table 1 displays the mean, standard deviation, and standard error of all variables, distinguished by group (experimental Synergy Mat and control AFA) and time (pre- and post-treatment).

		AFA group (control group)			SynergyMatt group (sperimental group)		
Variable	Time	Mean	Std. Deviation	Std. Error Mean	Mean	Std. Deviation	Std. Error Mean
TestDrawer	Pre	,47	,514	,125	,18	,393	,095
	Post	,47	,514	,125	,18	,393	,095
Race_TestFootAnkleDisability	Pre	1,59	,618	,150	1,53	0,72	0,174
	Post	3,29	,470	,114	4,00	0,00	0,000
Jump_TestFootAnkleDisability	Pre	1,47	,514	,125	1,41	0,51	0,123
	Post	3,29	,470	,114	4,00	0,00	0,000
Landing _TestFootAnkleDisability	Pre	1,47	,514	,125	1,35	0,49	0,119
	Post	3,41	,507	,123	4,00	0,00	0,000
CrouchingStopQuickly _TestFoo-tAnkleDisability	Pre	1,59	,712	,173	1,71	0,77	0,187
	Post	3,35	,493	,119	4,00	0,00	0,000
Lateral movements TestFoo-tAnkleDisability	Pre	1,59	,712	,173	1,71	0,77	0,187
	Post	3,24	,437	,106	4,00	0,00	0,000

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		AFA group (control group)			SynergyMatt group (sperimental group)		
Variable	Time	Mean	Std. Deviation	Std. Error Mean	Mean	Std. Deviation	Std. Error Mean
Light Activities TestFootAnkle-Disability	Pre	2,53	,717	,174	2,65	0,79	0,191
	Post	3,35	,493	,119	4,00	0,00	0,000
Moderate Activities _TestFoo-tAnkleDisability	Pre	1,65	,493	,119	1,71	0,47	0,114
	Post	3,29	,470	,114	4,00	0,00	0,000
Sport_TestFootAnkleDisability	Pre	1,53	,514	,125	1,65	0,49	0,119
	Post	3,41	,507	,123	4,00	0,00	0,000
SF36_ Physical Functioning	Pre	5,59	11,97	2,90	4,12	3,64	0,88
	Post	38,24	18,79	4,56	88,24	21,86	5,30
SF36_ Physical Health Limitations	Pre	2,94	12,13	2,94	2,35	3,12	0,76
	Post	60,29	33,93	8,23	97,06	12,13	2,94
SF36_ Limitations Emotional Pro-blems	Pre	2,94	12,13	2,94	2,35	3,59	0,87
	Post	86,47	31,21	7,57	94,12	16,61	4,03
SF36_ Energy Fatigue	Pre	7,06	11,87	2,88	4,12	4,41	1,07
	Post	93,82	17,64	4,28	74,41	34,00	8,25
SF36_ Emotional Well-Being	Pre	4,38	11,91	2,89	1,67	2,01	0,49
	Post	52,35	19,85	4,81	94,12	16,61	4,03
SF36_ Social Functioning	Pre	22,06	11,29	2,74	20,59	8,77	2,13
	Post	48,53	4,15	1,01	94,12	16,61	4,03
SF36_ Pain	Pre	20,29	10,89	2,64	17,94	8,02	1,94
	Post	51,18	13,29	3,22	94,12	16,61	4,03
SF36_ General Health	Pre	5,61	12,23	2,97	2,67	4,39	1,06
	Post	87,35	23,72	5,75	79,41	25,36	6,15

First, differences between the two groups were examined both before and after the treatment. The results are presented in Table 2.

Table 2. Independent t-Test; differences between the two groups (AFA group and Synergy Mat group) before treatment (pre-treatment) and after treatment (post-treatment).

	pre-treatment		post-treatment	
Variable	t	sig.	t	sig.
TestDrawer	1,83	>0.05	1,83	>0.05
Race_TestFootAnkleDisability	0,26	>0.05	-6,19	<0.001
Jump_TestFootAnkleDisability	0,34	>0.05	-6,20	<0.001
Landing _TestFootAnkleDisability	0,68	>0.05	-4,78	<0.001
CrouchingStopQuickly _TestFootAnkleDisability	-0,46	>0.05	-5,42	<0.001
Lateral movements TestFootAnkleDisability	-0,46	>0.05	-7,21	<0.001
Light Activities TestFootAnkleDisability	-0,45	>0.05	-5,42	<0.001
Moderate Activities _TestFootAnkleDisability	-0,36	>0.05	-6,19	<0.001

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	pre-treatment		post-treatment	
Variable	t	sig.	t	sig.
Sport_TestFootAnkleDisability	-0,68	>0.05	-4,78	<0.001
SF36_ Physical Functioning	0,97	>0.05	-7,15	<0.001
SF36_ Physical Health Limitations	1,00	>0.05	-4,21	<0.001
SF36_ Limitations Emotional Problems	1,00	>0.05	-0,89	>0.05
SF36_ Energy Fatigue	0,96	>0.05	2,01	<0.05
SF36_ Emotional Well-Being	0,92	>0.05	-6,65	<0.001
SF36_ Social Functioning	0,42	>0.05	-10,98	<0.001
SF36_Pain	0,71	>0.05	-8,32	<0.001
SF36_ General Health	0,93	>0.05	0,94	>0.05

It can be observed that initially the two groups did not show statistically significant differences for all the variables examined. However, after the treatment, statistically significant differences were found for nearly all variables.

Since not all variables showed differences, a t-Test was conducted by splitting the sample by group to assess the effectiveness of the two treatments (AFA and Synergy Mat).

Table 3. Independent t-Test. Effects of the training protocol (difference between pre- and post-treatment) or the use of Synergy Mat on the sample.

	AFA group (control group)		SynergyMatt group (sperimental group)	
Variable	t	sig.	t	sig.
TestDrawer	,00	>0.05	,00	>0.05
Race_TestFootAnkleDisability	-9,06	<0.001	-14,20	<0.001
Jump_TestFootAnkleDisability	-10,79	<0.001	-21,04	<0.001
Landing _TestFootAnkleDisability	-11,08	<0.001	-22,16	<0.001
CrouchingStopQuickly _TestFootAnkleDisability	-8,40	<0.001	-12,26	<0.001
Lateral movements TestFootAnkleDisability	-8,13	<0.001	-12,26	<0.001
Light Activities TestFootAnkleDisability	-3,90	<0.001	-7,10	<0.001
Moderate Activities _TestFootAnkleDisability	-9,98	<0.001	-20,14	<0.001
Sport_TestFootAnkleDisability	-10,74	<0.001	-19,69	<0.001
SF36_ Physical Functioning	-6,04	<0.001	-15,65	<0.001
SF36_ Physical Health Limitations	-6,56	<0.001	-31,18	<0.001
SF36_ Limitations Emotional Problems	-10,28	<0.001	-22,27	<0.001
SF36_ Energy Fatigue	-16,83	<0.001	-8,45	<0.001
SF36_ Emotional Well-Being	-8,54	<0.001	-22,79	<0.001
SF36_ Social Functioning	-9,07	<0.001	-16,14	<0.001
SF36_Pain	-7,41	<0.001	-17,03	<0.001
SF36_ General Health	-12,63	<0.001	-12,29	<0.001

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The following table provides a clear indication of the results found in the previous test. Although a difference between the two groups is evident, it is also notable that the adapted physical activity protocol (AFA group) shows significant positive results for the patients.

For instance, it is particularly interesting to observe the variable "Energy-Fatigue," which highlights that the adapted physical activity protocol is more effective than the use of the Synergy Mat.

Conclusions

The aim of this experimental study was to evaluate the effects of a 6 2 times per week weeks of Synergy Mat and Adapted Physical Activity (AFA) in the population between 22 and 32 years of age who have experienced a grade 1 or 2 ankle sprain, excluding those who were in conditions that totally limited ankle mobility. According to the results of the present study, proprioceptive ankle training, which includes stretching, mobilization, strengthening exercises and exercises with balance boards, and for one of the two groups also used Synergy Mat, also reported improvements in balance static and dynamic. Proprioceptive training in general increases proprioceptive function by up to 20%, even with a general somatosensory stimulation given by the combination of both passive and passive movement active (Eils E. et al., 2001). As regards the control group subjected to adapted physical activity alone, the results of the tests and evaluations have reported a general physical improvement, especially in the of subjects to be able to participate in a sport without time limits and in the performance of activities sport-specific, in the movement of the "squat" or squat and in lateral movements, succeeding without any difficulty in carrying them out. Lateral movements were very important for the correct proprioception of the tibiotarsal in movements, mainly those in load. On the aspect of health and emotional status, the data of the "control" individuals, reported that the quality of life and the ability to carry out the actions that characterize it, post-treatment of AFA, has improved slightly because not all the variables, some inherent to social life and were changed from pre-treatment, as opposed to treatment with Synergy Mat of the experimental group where the improvements were superlative in all fields. In fact, only adapted physical activity has reported improvements, not as significant as those reported by Synergy Mats, especially with regard to the extent of pain that limited the performance of "control" subjects (65% say that pain limits them than that of experimental subjects (pain perceived almost not at all). Compared to the pre-treatment data, the "experimental" subjects improved their performance and increased their sports and daily life skills to almost 100%, as well as an improvement in the evident (about 80% of subjects) on an emotional and social level, led to the lower feeling of pain at the level of the tibiotarsal joint with greater expression of the mechanics of the movement of the ankle itself. The use of the Synergy Mat proprioceptive platforms has given these subjects the opportunity, through a path with different platforms that emulate different surfaces with different levels of instability, optimize performance and recover the correct mobility of the ankle in a shorter time (Herring JA, 2014). The use of these platforms increases proprioceptive sensitivity and allows the subject to perform the correct biomechanics of movement, varying its speed, direction, acceleration (Pagella F. et al., 2018), representing an optimal tool for recovery functional and rehabilitative of the ankle joint with 1st or 2nd degree sprain outcome and for proprioceptive rebalancing, as well as a means for muscle strengthening of the tibiales, gastrocnemius and soleus, peroneal and plantar. The results of this study, although limited by the sample size, provide a starting point for future research, where the sample could be expanded and a control group with

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no treatment could be included. In conclusion, given these results, it is advisable to recommend a comprehensive approach for the patient, involving both a physiotherapeutic intervention using the Synergy Mat and an adapted motor protocol tailored to the patient's needs.

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