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Original article

THE INTEGRATION OF HYDROTHERAPY IN PHASE II ANKLE SPRAIN MANAGEMENT AMONG ELITE GYMNASTS: CLINICAL OUTCOMES AND RETURN-TO-SPORT PARAMETERS

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Abstract

Aim. Unfortunately, injuries are part in the life of athletes and one of the most important objectives in recovery periods is to minimize muscle loss as much as possible and maintain the body performance at the highest possible level. By applying hydrotherapy protocols over a period of 12 weeks, we aim for all these objectives to be achieved, even more, to prevent previously suffered microtraumas occurred during periods of intense effort on the entire kinetic chain.

Methods. The period of implementation of the experiment extends over 12 weeks from July to October 2024. The study will be done on 2 performance athletes aged between 19-21 years. The first athletes' group will use the classic method of recovery after ankle sprain of the 2nd degree through immobilization and conservative treatment, medication and elevation and basic exercises for mobilization of the joint, and the other group of athletes will be applied the experimental program through hydrotherapy and medical water Spa fixtures. Both athletes will be tested before and after recovery program. The applied tests were carried out in similar conditions, being 4 tests:

1) Single leg stance for ankle stability (30 sec maintaining position/ 30 sec with eyes closed)
2) Ankle mobility test (5 cm from the big toe to the wall, the feet flat on the ground and the knee should be able to touch the wall)
3) Heel raises (lower body endurance and resistance) – 30-50 repetitions without fatigue
4) Single leg heel raises – 10-15 repetitions with 1"iso hold and controlled descent

The experimental patient, throughout the recovery period, used the following program:

- 1st and 2nd week – 3/week – 10-20 minutes/sessions.
- 3rd to 6th week – 3/week -25-45 minutes/sessions.
- 6th to 8th week – 4-5/week – 40-50 minutes/sessions.
- 8th to 12th week – 5/week -50 minutes/exercises + 10 minutes Spa recovery sessions.

Results. Applying the proposed recovery plan, we managed to considerably improve the results of the 4 tests in the experimental patient compared to control patient, emphasizing the importance of movement during the recovery period, the benefits of water, and also maintenance of tonicity and muscle yield.

Conclusions. The hypothesis of the experiment was confirmed, applying this recovery program for a period of 12 weeks, it is possible to work conservatively even through the appearance of exercises during the recovery period, being possible to maintain the musculature of the lower body and the functionality and stability of the ankle, even to adapt it easier for the specific effort.

Keywords: Exercises, hydrotherapy, mobility, movement, recovery.

Introduction

In the largest epidemiological study of ankle sprains in the general population of the world, Waterman et al. showed an incidence rate of 2.15 per 1,000 person years, making this injury one of the most common presenting complaints to the emergency department (Waterman et al., 2010). The peak incidence of ankle sprains occurs between ages 15 and 19, with an average age of 26 years old. Males and females do not demonstrate a statistically significant difference in incidence overall; however, between ages 15 and 24, males have a higher incidence rate. Sports that involve repetitive cutting, running, jumping, and frequent player contact have the highest incidence of ankle sprains. 49 % of all sprains occur during athletic activity, with basketball (41.1 %), football (9.3 %), and soccer (7.9 %) accounting for the highest percentages. 47.9 % of sprains occur at home, with 28.5 % occurring at a place of recreation (0. The average patient will miss 2.5 weeks of work, with 90 % of patients returning to work after 6 weeks. 60–90 % of athletes will resume sports at the same level as before the injury by 12 weeks (0. At 1 year after injury, 5–33 % of patients still have pain and

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complaints of instability, and between 3 % and 34 % of patients will have had recurrent sprain (0. Functional instability can also be thought of as persistent instability despite absence of pathological laxity on exam. The primary cause of such functional instability is injury to the joint mechanoreceptors and afferent nerves resulting in impaired balance, reduced joint position sense, slowed firing of the peroneal muscles in response to inversion stress, slowed nerve conduction velocity, impaired cutaneous sensation, strength deficits, and decreased ankle dorsiflexion. Functional instability typically responds well to a thoughtful rehabilitation program. Mechanical instability, on the other hand, may occur because of adverse anatomical changes due to structural damage of the ligamentous tissues resulting in laxity. (Caputo et al., 2009). Mechanical instability can lead to altered joint kinematics and arthritic changes, which often require surgical intervention (0. Mechanical and functional instability can occur concurrently in a patient making treatment more complex. Based on the directions that are mentioned above, we intent to develop a complex rehabilitation program for this condition, not only with conservative treatment methods (Ex: immobilization ,thermotherapy),we want to adapt it to the needs of an athlete, to maintain the muscles without any mechanical loss, even to improve the ROM, and to have a better capacity to adapt in effort after the rehabilitation phase.

Gymnastics requires jumping, changing direction, and pivoting, all of which significantly increase the risk of ankle sprains. Research demonstrates that after an initial ankle sprain, athletes face a substantially higher risk of subsequent sprains, making prevention crucial in gymnastics conditioning programs. Studies have shown that incorporating proprioceptive training can effectively reduce the risk of ankle injury. Proprioception, defined as the process by which the body takes in sensory input from the environment and integrates that information to produce a motor response, plays a vital role in injury prevention (0. A comprehensive review of well-designed research articles revealed that proprioceptive exercises can reduce the overall risk of ankle injury in athletes by approximately 35%. For athletes with previous ankle injuries, these exercises can decrease the risk of re-injury by about 36%, while in athletes without prior ankle injuries, the risk reduction can reach around 43% (0.

Based on these findings, we intend to develop a complex rehabilitation program for this condition that goes beyond conservative treatment methods. Our aim is to adapt it specifically to the needs of athletes, focusing on maintaining muscle function without mechanical loss, improving range of motion (ROM), and enhancing post-rehabilitation effort capacity. This approach will incorporate progressive proprioceptive training, utilizing equipment commonly found in gymnastics facilities, with exercises ranging from basic balance work on stable surfaces to more advanced techniques involving unstable surfaces and dynamic movements.

Objectives

The research aims to identify other methods except the conservative treatments in rehabilitation programs for athletes with an ankle sprain through:

- The effect of the rehabilitation program on the range of motion of the ankle
- The effect of the rehabilitation program on the degree of pain
- The effect of the rehabilitation program on some physical variables of the working muscles (minimize the loss of the functional muscles in the phase of rehabilitation)

Hypotheses

1) There are statistically significant differences between the averages of the pre-and post-measurements of the experimental group in the effect of the proposed rehabilitation program on the range of motion of people with an ankle sprain ph.II , in favor of the averages of the post-measurements.
2) There are statistically significant differences between the averages of the pre-and post-measurements of the experimental group in the effect of the proposed rehabilitation program on the degree of pain among people with an ankle sprain ph.II, in favor of the averages of the post-measurements.
3) There are statistically significant differences between the averages of the pre-and post-measurements of the experimental group in the effect of the proposed rehabilitation program on some physical variables (under investigation) among people with an ankle sprain ph.II, in favor of the averages of the post-measurements.

Methods

Participants:

The research used the experimental method for 10 gymnastic athletes with the same diagnosis, aged between 19-21 years, through two measurements, the pre- and the post-method, as it suits the nature of the research.

Study design:

The research used the experimental method for the Experimental Athlete, where we will use the rehabilitation program that uses joint mobilization movements, hydrotherapy sessions, hydro-thermotherapy, and medical spa procedures.

Procedures

Aid and equipment:

1) Medical scale Tanita MC-780U PLUS to measure the weight and height
2) Patient information from the doctors- medical anamnesis and information release forms

3) Goniometer to measure the range of motion
4) Measuring the degree of pain. The patient's degree of pain is determined by the pain score from (0-10) and then asking the patient and look at his facial expression and the score is given out of (10) using the (Numerical pain scale).
5) A series of test that indicate functionality and stability of the ankle:
    a) Single leg stability test (performed with eyes open/eyes closed) – with a system rating from 0-5.
    b) Heel raises endurance test -with a system rating from 0-5.
    c) Single leg heel raises endurance& strength – with a system rating from 0-5.
    d) Ankle mobility test (in front of the wall we start with a 5-10 cm distance from the big toe to the wall, the patient should be able to touch the wall with the knee without raising the heel from the ground)- with a system rating from 0-5.

Table 1. The pain degree from VAS scale

No pain	0
Simple pain	3, 2, 1
Moderate pain	6, 5, 4
Severe pain	10, 9 ,8 ,7

Table 2. Goniometer measure ROM (range of motion) of ankle

Movement	**Eversion**	**Dorsal flexion**	**Plantar flexion**	**Inversion**
1pt	0-5°	0-5°	0-10°	0-5°
2pt	5-10°	5-10°	10-20°	5-10°
3pt	10-15°	10-15°	20-30°	10-20°
4pt	15-20°	15-20°	30-35°	20-30°
5pt	20°(without limits)	20-25°	35-40°	30-40°

Table 3. Rating and scaling of the tests for ankle stability, endurance and functionality

Test	**Single leg – EO**	**Single leg-EC**	**Heel raises**	**SL heel raises**	**Ankle mobility**
1pt	5-10"	5-10"	0-5 rep	0-3 rep	0-2 cm
2pt	10-15"	10-15"	5-10 rep	3-6 rep	2-4 cm
3pt	15-20"	15-20"	10-15 rep	6-9 rep	4-6 cm
4pt	20-25"	20-25"	15-20 rep	9-12 rep	6-8 cm
5pt	25-30"	25-30"	20-30 rep	12-15 rep	8-10 cm

Survey study:
The study was done from 1/7/2024 to 1/10/2024 on a sample patient from the Visa Med Clinique, Constanta.
The suggested rehabilitation program:
The rehabilitation program was designed for the member of the sample under study as the following:
- View the specialized scientific references in the field of rehabilitation of an ankle sprain ph.II, and through analyzing the rehabilitation programs used in the related reference studies and research
- Medical observation in the Clinique from the specialist doctor
- The rehabilitation program was made for athletes with ankle sprain ph.II and whose cases don't require surgical interference

Objectives of the rehabilitation program:
- Finding the balance between the muscle groups working on both sides of the inferior chain muscles to avoid atrophy;
- Strengthening the weak muscles groups working on one side of the foot involving all the others muscle from the inferior chain;
- Reducing the severity of pain;
- Improve range of motion;
- Finding new methods for rehabilitation that can help the athletes to improve muscles stability, balance, and adaptation to the specific training after injury.

Fundamentals of implementing the rehabilitation program:

- Pay attention to the preparation and always a good and proper warm-up that is appropriate to the nature of the injury;
- Gradual load intensity during the implementation phase;
- Exercises will be done from easier to more difficult;
- Apply the program individually according to each one of the patients and the specific method of rehabilitation(conservative/experimental);
- The total time for each patient is 12 weeks;
- The numbers of time of the rehabilitation program for experimental patient will be applied like this:
    - 1st and 2nd week – 3/week – 10-20 min/session;
    - 3rd to 6th week- 3/week – 25-45 min/session;
    - 6th to 8th week- 4/week – 40-50 min/session;
    - 8th to 12th week-5/week- 50min/session + 10 min Spa recovery session;
- Taking into account the physiological principle in implementing the training and rehabilitation unit;
- Taking into account giving appropriate rest periods between rehabilitation sessions;
- Continuity and regularity so as not to lose the effect of the exercise in the previous units;
- When implementing, attention should be paid to rehabilitation of the muscle groups affected by the injury, as well as the muscle groups that contribute to the rapid return of the affected area to its normal state.

Program implementation stages:

The experimental rehabilitation program will be divided in 4 stages which are:

Phase 1 (1st and 2nd week) it aims to:

- Reduce the pain;
- Reduce the swelling process with the help of *hydrotherapy principles* (hydrostatic pressure, different levels of immersion/emersion for stimulating blood circulation, and an envoirment without pressure on the ankle joint);
- A better blood stimulation with *thermo-hydrotherapy* (Kneipp cure- small pools with 15°C water and 40-42°C water);
- This stage is *based on simple exercises* to educate the normal walking pattern (walking variations exercises) and *simple swimming movements* for lower body without adding force just for joint mobilization (ex: freestyle wide kicking, bicycle kick, lateral kick, scissor leg movement).

Phase 2 (3rd to 6th week) it aims to:

- Increase the muscle strength for working muscles on the lower body;
- Gain a better ROM for movements of ankle;
- Increase the functional efficiency of the legs muscle and start to do variations of movement and direction changes with the help of the feet;
- Start to add isometric exercises for regaining stability in the joint junction;
- Start to add some equipment for muscles conditioning and joints mobilization for lower body extremity (underwater bicycle, underwater treadmill, noodles);
- The swimming exercises start to be doing on 30-50% of power, with intensity changes and timed intervals for work and pause.

Phase 3 (6th to 8th week) it aims to:

- Prepare the individual to practice the requirements of his daily life;
- Prepare the ankle joint for impact absorption with dedicated exercises (deceleration exercises);
- Add plyometric exercises to improve the overall strength and explosion;
- Add exercises with different stimulus to improve the reaction time (waiting command to change directions, to react to sound as fast as he can);
- The swimming exercises start to be above 60-70% of power with bigger rounds of exercises to improve the endurance.

Phase 4 (8th to 12th week) it aims to:

- Add the specific training of athletes each one of them are using the specific of his sport;
- The sessions aim for hypertrophy, endurance, strength and effort capacity increase;
- Every exercise now can be done with full power 100%;
- After every session we will use different medical spa treatments for muscle recovery (hot/cold water tubs, hydromassage, dry sauna, therapeutic massage);
- The main purpose of this phase is to help the athlete to return and to be able to sustain the specific training of his sport.

The other patient will follow the classic conservative treatment that includes:

- 4-8 weeks joint immobilization;
- Thermotherapy;
- Medication;
- After immobilization phase start with simple exercises in bed;

- Last 4 weeks start working basic exercises without exciding 20-40% of loading.

Results

It has been done from 1/07/2024 to 1/10/2024 on some variables of the previous one.

Table 4. Pre-measurement for Conventional Therapy Group in the ROM of ankle tests

	Eversion	Inversion	Dorsal Flexion	Plantar Flexion	Total Score
Patient 1	1pt- 3°	1pt-5°	2pt-8°	3pt-13°	7 pt
Patient 2	1pt-4°	1pt-0°	2pt-6°	2pt-10°	6 pt
Patient 3	1pt-5°	2pt-6°	1pt-5°	2pt-11°	6 pt
Patient 4	2pt-6°	2pt-8°	2pt-8°	2pt-16°	8 pt
Patient 5	1pt-2°	1pt-0°	1pt-1°	1pt-10°	4 pt

Table 5. Pre-measurement for Experimental Therapy Group in the ROM of ankle tests

	Eversion	Inversion	Dorsal Flexion	Plantar Flexion	Total Score
Patient 6	1pt- 4°	2pt-5°	1pt-5°	2pt-10°	6 pt
Patient 7	1pt- 5°	1pt-5°	1pt-3°	2pt-10°	5 pt
Patient 8	2pt-6°	2pt-6°	2pt-7°	2pt-12°	6 pt
Patient 9	2pt-7°	2pt-6°	2pt-8°	1pt-8°	7 pt
Patient 10	1pt-0°	1pt-0°	1pt-0°	1pt-3°	4 pt

Table 6. Pre-measurement for Conventional Therapy Group in the ankle stability, endurance and mobility tests

Test	Single leg eyes open	Single leg eyes closed	Heel raises	Single leg heel raises	Ankle mobility	Total score
Patient 1	2pt-14"	2pt-12"	1pt-5 reps	1pt-0 reps	1pt- 1cm	7 pt
Patient 2	2pt-12"	2 pt-11"	2 pt-6 reps	1pt-0 reps	1pt- 2cm	8 pt
Patient 3	2pt-11"	2 pt-10"	2 pt-7 reps	1pt-1 reps	1pt- 2cm	8 pt
Patient 4	2pt-10"	1pt-8"	2 pt-7 reps	1pt-1 reps	1pt -2 cm	7 pt
Patient 5	1 pt-8"	1pt-6"	1 pt-5 reps	1pt-0 reps	1pt -1 cm	5 pt

Table 7. Pre-measurement for Experimental Therapy Group in the ankle stability, endurance and mobility tests

Test	Single leg eyes open	Single leg eyes closed	Heel raises	Single leg heel raises	Ankle mobility	Total score
Patient 6	2 pt- 12"	2pt-10"	2pt- 6 reps	1pt -1 reps	1 pt -2cm	8 pt
Patient 7	2 pt- 11"	2pt-10"	2pt- 6 reps	1pt- 1 reps	1pt – 2 cm	8 pt
Patient 8	2pt- 10"	1pt- 8"	1pt-4 reps	1pt- 0 reps	1pt -1 cm	6 pt
Patient 9	1pt- 8"	1pt- 6"	1pt- 5 reps	1pt- 0 reps	1pt- 1 cm	5 pt
Patient 10	1pt- 6"	1pt- 4"	1pt- 2 reps	1pt- 0 reps	1pt- 1 cm	5 pt

Table 8. Post-measurement for Conventional Therapy Group in the ROM ankle tests

	Eversion	Inversion	Dorsal Flexion	Plantar Flexion	Total Score
Patient 1	3 pt- 10°	3 pt-10 °	3 pt-12 °	3 pt-23 °	12 pt
Patient 2	3 pt-12 °	3 pt-12 °	3 pt- 12 °	3 pt-25 °	12 pt
Patient 3	4 pt-15 °	4 pt-21 °	4 pt- 17 °	4 pt-32 °	16 pt
Patient 4	4 pt-17 °	4 pt-23 °	4 pt- 20 °	4 pt-34 °	16 pt
Patient 5	3 pt-10 °	3 pt-20 °	3pt - 10 °	3 pt-20 °	12 pt

Table 9. Post-measurement for Experimental Therapy Group in the ROM ankle tests

	Eversion	Inversion	Dorsal Flexion	Plantar Flexion	Total Score
Patient 6	4 pt- 15°	5 pt-30 °	4 pt-19 °	5 pt-36 °	18 pt
Patient 7	4 pt-17 °	5 pt-33 °	4 pt- 18 °	5 pt-35 °	18 pt
Patient 8	5 pt-20 °	5 pt-37 °	5 pt- 22 °	5 pt-38 °	20 pt
Patient 9	5 pt-20 °	5 pt-38 °	5 pt- 24 °	5 pt-40 °	20 pt
Patient 10	4 pt-15 °	4 pt-29 °	4 pt -18 °	4 pt-32 °	16 pt

Table 10. Post-measurement for Conventional Therapy Group in the ankle stability, endurance and mobility tests

Tests	Single leg-eyes open	Single leg eyes closed	Heel raises	Single leg heel raises	Ankle mobility	Total score
Patient 1	3pt-15"	3pt-15"	3pt-14 reps	2 pt-6 reps	2pt- 4cm	13 pt
Patient 2	3pt-15"	3 pt-16"	3pt-15 reps	2 pt-6 reps	2pt- 4cm	13 pt
Patient 3	4pt-21"	4 pt-20"	4pt-16 reps	3 pt-7 reps	3pt- 5cm	18 pt
Patient 4	4pt-22"	4 pt-20"	4pt- 7 reps	3 pt-9 reps	3pt -6 cm	18 pt
Patient 5	3 pt-15"	3 pt-15"	3pt-11 reps	1 pt-3 reps	2pt -3 cm	12 pt

Table 11. Post-measurement for Experimental Therapy Group in the ankle stability, endurance and mobility tests

Tests	Single leg eyes open	Single leg eyes closed	Heel raises	Single leg heel raises	Ankle mobility	Total score
Patient 6	4pt-20"	4pt-20"	5pt-21 reps	4pt-10 reps	5pt- 9cm	22 pt
Patient 7	4pt-22"	4 pt-20"	5pt-23 reps	4pt-12 reps	5pt- 10cm	22 pt
Patient 8	5pt-28"	5 pt-26"	5pt-28 reps	5pt-15 reps	5pt- 10cm	25 pt
Patient 9	5pt-30"	5 pt-28"	5pt-30 reps	5pt-15 reps	5pt -9cm	25 pt
Patient 10	4 pt-23"	4 pt-21"	4pt-20 reps	4pt- 9 reps	4pt -7cm	20 pt

Table 12. Total Score for Pre-/Post-measurements and %DIF in efficiency for treatment methods

		Pre-measurement Total Score	Post-measurement Total Score	DIF %
Conventional Group	Therapy	66 pt	142 pt	
Experimental Group	Therapy	60 pt	206 pt	+31,07% EXP Group

Discussions

Through the apparent results of measuring the range of motion of the ankle joint (Eversion - Inversion – Dorsal flexion – Plantar flexion) and after performing the therapeutic rehabilitation program and the values measured in the tables (table 4) which expresses the motion range of the ankle join for those who suffer from ankle sprain phase II. Through the apparent results of measuring the range of motion after the experimental rehabilitation program indicates the validity of the program, ease of movement, better ROM. Through the apparent results of measuring the stability, joint mobility and joint endurance in the tables (5-6-7), indicates the validity of the program, with better functionality, with significant stability even on the healthy ankle we have improvement, and better endurance which indicates the fact that if all the muscles from the lower body extremity it is involved in the rehabilitation program the weak spots from the pre- measurement will be improved. The difference between the conservative treatment and the experimental treatment are notable we have ≅ 30% difference in all tables of measuring. Rehabilitation programs have addressed the impairments identified in *CAI (Chronic Ankle Instability*) with a focus on strengthening and balance impairment. The evidence clearly demonstrates that balance programs for those with CAI not only improves postural control but also reduces recurrent ankle sprains (0 and the prevalence of functional ankle instability. Exercise also is associated with a quicker time to recovery and enhanced outcomes. Most intervention studies have focused on interventions that target one or more of the impairments. For example, joint mobilization interventions have primarily improved dorsiflexion ROM as well as postural control (0, (0. Balance training pro-grams have improved static and dynamic postural control (0. Ankle-strengthening programs have improved ankle strength (0. Many of these interventions have also demonstrated the ability to enhance ankle-specific patient-reported outcomes (PROs) (0. It was concluded that functional exercises and activities, especially utilizing unstable surfaces, promote improvement in dynamic postural control (0. This is consistent with a predominance of evidence supporting improvements in measures of postural sway for individuals with CAI who undergo progressive balance retraining programs (0, (0, (0, (0, (Han, Ricard & Fellingham, 2009), (Wright, Arnold, Ross & Linens, 2014) . Controlled trials that have combined balance exercise and manual therapy have shown improvements across clinician and patient-- focused outcomes, but the follow-up time remains limited (0. Current and future studies are beginning to identify those most likely to benefit from rehabilitation; however, this has currently only

identified specific characteristics linked to interventions. For example, those with >3 balance test errors had a 73% probability of treatment success following ankle mobilization, and participants that reported between limb differences <16.07% and who made >2.5 errors had a 99% probability of treatment success with plantar massage (0. In summary, exercise programs that incorporate balance and strengthening have positive effects on improving balance and patient-reported clinical outcomes in those with CAI. However, the clinical endpoint from these programs has not been investigated over longer-term follow-ups. The potential for these rehabilitation programs to reduce risk for further injury, return to sport, and improve overall outcomes after 1 year remains an area of ongoing study.

Conclusions

The hypothesis promoted in the research are all valid:

- Using the rehabilitation program that included the rehabilitation exercises had a clear positive impact on the research variables (ROM- stability- endurance- the strength of the working muscles).
- There are statistically significant differences in the percentage of improvement between the averages of the pre- and post- measurements in the effect of the proposed rehabilitation program on ROM (inversion- eversion- dorsal flexion- plantar flexion), on stability tests (single Leg stance with eyes open/closed), on endurance tests (double heel raises, single leg heel raises) and mobility test, with an improvement of almost 30% in post measurements in all the segments of testes.
- There are statistically significant differences between the pre- and post- measurements in the experimental patient which indicates the impact of the suggested rehabilitation program on the all factors improvement, that suggest the importance of the movement in the rehabilitation phase for athletes, the gradually load and mobilization of joint, and the muscle conditioning.

Recommendations

- The importance of providing rehabilitation on a program that includes gradual movements is treating the injured to return to a healthy position
- Work on using more than one rehabilitation and therapeutic program for use in treating an ankle sprain
- Encourage patients on the importance of using rehabilitation programs between long periods of hard training
- Pay attention to developing and strengthening the muscle chain of the lower limbs, and all the functional muscles to avoid injuries easily

Author contributions

All authors contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript. All authors have read and agreed to the published version of the manuscript.

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