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Original Article

The "Bad Ragaz Ring Method" aquatic therapy for improving balance in football players aged 11-12 with ankle sprains

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Abstract
The aim of this research is to assess the effects of the aquatic prevention and rehabilitation program on balance in junior football players with ankle sprains by testing the limits of stability (LoS) following the application of the aquatic prevention and rehabilitation program (hydrokinetic therapy, Bad Ragaz Ring Method (BRRM), technical elements and procedures specific to the football game) and land physical therapy. *Methods* Twenty-two junior football players (11- 12-year-olds) was divided into experimental and control groups diagnosed with ankle sprains participated in the research.The experimental group performed the physical therapy program: BRRM, aquatic prevention and rehabilitation program, whereas the control group only performed the land physical therapy program. The Balance Trainer BTG4 platform allowed us to test the LoS by analyzing 4 parameters: anterior tilt, posterior tilt, left lateral tilt, right lateral tilt. *Results* The results showed that both programs were effective, but the comparison between the level of the evaluated parameters showed higher indices in the experimental group compared to the control group. The program applied to the experimental group produced improvements of balance in soccer athletes with ankle sprains. *Conclusions* The comparative analysis between the initial and final testing, in each group, indicates progress in terms of the balance. The comparative analysis between the groups clearly shows that the program developed for the experimental group (BRRM, physical therapy on land and in the aquatic environment, with technical elements specific to the game of football) have led to significant improvements.
Keywords: aquatic therapy, ankle sprain, balance, football

Introduction

Acute injuries of the ankle are among the most common injury of the musculo-skeletal system, states most specialists including Polzer, Kanz, Prall, Haasters, Ockert, Mutschler, Grote (2012). The prevalence of ankle sprains, associated with high recurrence rates, persistent impairments, the deterioration of the ankle's functional ability, and long-term sequelae represent a real public health burden (Vuurberg et al., 2018). The authors Thompson, Byrne, Williams, Keene, Schlussel, Lamb (2017), who quote numerous specialists (Schaap et al., 1989, Verhagen et al., 1995, van Rijn et al., 2008), stating that a third of those injured with ankle sprains have long-term painful symptoms. They state, agreeing with a study by the autors Konradsen, Bech, Ehrenbjerg, Nickelsen (2002), that 32% of the 648 studied subjects experienced pain, inflammation, and relapses over a period of 7 years. Various other studies show that for 2.5 up to 5 years post-ankle sprain, 30% of injured individuals experienced pain, and some research by Anandacoomarasamy, Barnsley (2005) reported that 74% of the studied individuals experienced pain symptoms and weakness, or instabilities between 1 and 4 years after the ankle sprain.

In the United States, approximately 2 million acute ankle sprains occur annually, affirmed Herzog et al. (2019). These dates from emergency department visits. According to Cooke et al. (2009) it is estimated that ankle sprains account for up to 1.5 million visits to UK emergency departments each year. Another study (Cooke et al., 2003) states that sprains of the lateral ligaments of the ankle joint account for between 3% and 5% of all emergency department attendances in the UK, with about 5600 injuries each day. The same authors founded that in the Netherlands, an incidence rate of 37.5 and 17.5 per 1000 person-years during sporting activities and activities of daily living respectively and regarding daily activities, Kemler, van de Port, Valkenberg, Hoes, Backx (2015) states that was reported over a 10-25 year period.

Similar results were found in Swedish elite athletes, with 65%–95% of them reporting at least one injury during a single season (Hägglund, Waldén, & Ekstrand, 2009). Halabchi & Hassabi, (2020) showed in their study that acute ankle sprain is the most common lower limb injury in athletes and accounts for 16% - 40% of all sports-related injuries. Edvardsson, Ivarsson, Johnson (2012) state after (Bauer and Steiner, 2009) that over 8 million medically treated sports injuries are estimated annually in Europe. Referring to a study by Ekstrand et al. (2011) focused on elite European football, the same authors found that on average players suffered two

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injuries per season. In the United States, the prevalence of football injuries reported by emergency hospitals is estimated to be approximately 88,000 children aged 5-14 years. In Finland, for example, Ristolainen, Heinonen, Waller, Kujala, and Kettunen (2009) found that 92% of male Finnish elite soccer players and 79% of female Finnish soccer players reported at least one injury per year.

It is a well-known fact that balance is very important in sports performance, being necessary for several sports skills, such as changing direction, stopping, starting, holding, kicking the ball or holding the body in a certain position. If balance is not achieved in a short period of time, the athlete can get injured, stated Bihter, Kocahan (2015). Ensuring an efficient, fast recovery (in the event of injury) and without the possibility of relapse has become a central objective of sports training. The search for new methods of returning to the sporting activity, the transfer of rehabilitation methods from one condition to another, the attempt to see their effectiveness must be the prerogative of physiotherapists and of the "head" coach, who will also produce the athlete capable of exceptional performances. As a rule, ankle sprain is treated superficially, with the continuation of training and matches, the application of an ointment or of an **elastic bandage**, which will cause in the long-term soreness or greater destruction, withdrawal for longer periods, or even abandoning sports performance (Melanson, Shuman, 2023). The present research is focused precisely on the previously emphasized points, with the intention of finding new, innovative solutions for the rehabilitation of football athletes after ankle sprain accidents, and of proposing an aquatic prevention program able to improve balance. Aquatic rehabilitation is a well-known approach, which is useful for the prevention and management of many conditions (Coraci et al. 2022). Aquatic therapy is a viable method of injury prevention, providing a low-impact environment, where athletes can increase their strength, endurance and improve their balance without overstraining their body (Buckthorpe, Pirotti, Villa, 2019). Its application to athletes is quite common in clinical practice, more and more specific techniques (Watsu, Ai Chi, Halliwick, Bad Ragaz Ring Method) being used in order to accelerate rehabilitation and achieve optimal long-term results (So, Ng, Au, 2019).

There is some research on aquatic therapy for the rehabilitation of athletic injuries. The systematic review, by Eunkuk Kim and Hokyung Choi (2014), assesses the evidence for the effectiveness of aquatic therapy in the treatment of athletes and/or people with sports injuries. They suggest the fact that athletes and/or individuals who underwent aquatic physical therapy for sports injuries rehabilitation showed an improvement of range of motion, muscle strength, balance ability, and performance. Therefore, it was not possible to determine from this review the ideal aquatic physical therapy program, which is necessary during the rehabilitation of a specific sports injury in order to achieve clinically significant benefits. One of the articles in this review showed that ankle's functional ability improved after hydro-kinesiotherapy for up to 3 months and only 4 (17%) of the 24 athletes who fulfilled the aquatic program re-injured their ankles, while 8 (35%) of the 23 athletes who participated in the physical therapy program re-injured themselves. A high rate of ankle sprain recurrence was reported in athletes who had residual symptoms, such as pain, inflammation, weakness, and instability, and this occurrence of multiple episodes of ankle sprain and ankle instability is referred to as chronic ankle instability (Nualon *et al.*, 2013).

Ankle instability was a prognostic factor associated with relapse in athletes with ankle sprains. The prevention and early detection of ailments/possible predispositions to injuries are essential in terms of optimizing sports participation and performance. Particularly important is recovery, which must focus on effective prevention and rehabilitation programs, so that relapse does not occur. This research assesses the effect of the aquatic prevention and rehabilitation program on the balance of junior football players with ankle sprains. In this research, we have investigated the balance by testing the limits of stability (LoS) in junior football players with ankle sprains after the application of the aquatic prevention and rehabilitation program (hydrokinetic therapy, the Bad Ragaz Ring Method, and technical procedures specific to the football game), associated with physical therapy.

Materials and methods

*Participants.*Twenty-two junior football players (aged 11 to 12 years) with ankle sprains participated in the research. They were divided into two groups (experimental and control). Each of the subjects was randomly selected into the experimental or the control group, after they sustained the injury and showed up at the recovery center with the recommendation and diagnosis of the specialist doctor. 12 athletes were included in the experimental group (6 subjects had first-degree ankle sprains; 6 subjects had second-degree ankle sprains), and 10 athletes were included in the control group (4 subjects had first-degree ankle sprains; 6 subjects had second-degree ankle sprains). The experimental group fulfilled the physical therapy program, to which the independent variable BRRM + aquatic prevention and rehabilitation program (PPRA) was added, whereas the control group only fulfilled the physical therapy program.

The recovery programs were established according to the objectives pursued, adapted to each individual case, specific to the condition and structured in three stages. The materials used for the physical therapy program were: balance board, elastic band, gymball, gym bench, medicine ball, trellis, Pad, Bosu hemisphere, stepper, soccer ball. The aquatic prevention and recovery program (PPRA) included the hydrokinetotherapy program, (where materials specific to the aquatic environment were used: rafts, swimming paddles, foam sticks, aquatic

bicycle), aquatic program with elements and technical procedures specific to the game of football (dribbling, rolling, driving, shooting with a sand ball) and the Bad Ragaz Ring Method (physiotherapist, cervical collar and foam sticks provide resistance and stability to the patient). The Bad Ragaz Ring Method (BRRM) is a resistive strengthening and mobilization exercise model based on the principles of proprioceptive neuromuscular facilitation techniques (Gianfaldoni et al., 2017). BRRM is not simply a matter of working against the resistance of water and adding a fixed point to a patient floating in supine with buoyancy rings and then asking for active movements (in straight planes). The patient must be evaluated with an emphasis on determining the intervention needs. As a result, the therapist chooses the adequate patterns and parameters. Physiological parameters differ depending upon the therapeutic goal such as increasing mobility, endurance or strength. The exercise program of the BRRM requires flotation aids that provide patient safety and stabilization in the water. These flotation aids also slow down rotation of the body in the pool. The neck and hips are supported by rings preferably filled with air, and depending on the exercise, a third ring may support one or both ankles (Harrison 1982).

This method aims to facilitate functional movement by using concentric, eccentric and isometric muscle contractions, thus increasing joint mobility and reducing muscle fatigue (Kevin et al., 2013). The Bad Ragaz Ring method comprises three models for the trunk, upper limbs and lower limbs. They are also classified as unilateral or bilateral. Bilateral methods are defined as symmetrical or asymmetrical, states Stan (2016). The models are made in a floating supine position or for some models of the upper limbs they are made in an inclined position and for some models of the trunk they are in a lateral position. The water temperature must be between 33°-35°C. To understand the principles of how the BRRM function, it is necessary to analyze how chains of movements in the body function as well as how they influence equilibrium. This is especially important for the bilateral asymmetric reciprocal leg patterns (Urs et al., 2017).

Procedure. The research took place over a period of 8 months, starting from February 2022 and ending in September 2022. The frequency of application of the rehabilitation program was 3 times a week, in sessions sessions of 35 min to 90 min for the first degree of ankle sprain and of 35 min to 120 min for the second degree. The rehabilitation program varied according to the degree of ankle sprain (first degree – 3 to 4 weeks, second degree - 8 weeks).

Instruments. The Balance Trainer BTG4 HUR balance platform allowed us to test the Limits of Stability (LoS), which analyzed 4 parameters, namely: anterior tilt, posterior tilt, left lateral tilt, right lateral tilt. The analysis and recording of the results were done with the help of the HUR SmartBalance software.

Fig. no. 1 Balance testing – The Limits of Stability (LoS) in the anterior-posterior and medio-lateral directions.

The Limits of Stability (LoS) are defined as the points where the center of gravity approaches the limits of the base of support; in other words, the limits of stability represent the maximum amount of movement that a person can intentionally make, in any direction, without losing his/her balance (Johansson et al., 2019). People who have a low stability limit have an increased risk of injury caused by falling, when they shift their body weight forward, backward, or sideways and are, thus, prone to trauma.Were included in the study, after their and their guardian's consent and after the disappearance of the pain and inflammation, being assessed for the initial testing. Then they went through the recovery, and at the end they were tested for the final assessment.

Test protocol. In order to test the limits of stability, the subjects performed anterior, posterior, lateral, and medial trunk/torso tilts, holding each position for 8 s, without lifting their sole off the ground. The interpretation of the results regarding the limits of stability states that the normal swing angle in the anterior-posterior direction should be 7°, respectively 5°, and for the medio-lateral direction approximately 8° (Juras *et al.*, 2008).

Statistical analyses. All statistical data analyses were performed using SPSS software, version 22.0. For data analysis, the mean and standard deviation. The existing differences of the value populations, between the initial and the final testing, were obtained by applying the Student's t-test for dependent (correlated) samples of small volume. The same applies in the comparative analysis between the experimental group and the control group, the Student's t-test for independent (uncorrelated) samples of small volume (Simion, 1998). The effect size analyze the cause and effect relationship of the independent variable to the dependent variable and can be interpreted as

follows: ES>0.8 is large, ES around 0.5 is medium, and ES<0.2 is small. If the ES value is high, it can be considered that the cause-effect relationship is important, or that the change in training intensity has a significant influence (Thomas, Nelson, 1990).

The results of the research and discussion

Anterior tilt. During the final testing of the experimental group for *anterior tilt*, an increase of 1.905^0 is recorded compared to the initial testing, therefore if during the initial testing the mean value $\bar{x}$±Ds =5.017±1.163^0 was obtained, during the final testing the mean was $\bar{x}$±Ds =6.922±1.104^0. The application of the Student's t-test between the initial and the final assessment shows us the value t=5.673, as well as statistically significant values (p<0.0005). The coefficient of variability shows us an inhomogeneous group (TI – CV=23.181%, TF –CV= 14.649%). The arithmetic mean of the values obtained in the control group following the assessment of the limits of stability for the *anterior tilt* during the initial testing was $\bar{x}$±Ds =5.686±0.807^0, and for the final testing it was $\bar{x}$±Ds=5.809±1.401^0, the difference between the means being 123^0. Following the application of the dependent Student's t-test between the two assessments, the value 0.43^0 was obtained, the difference between the means being statistically insignificant at p>0.05. The coefficient of variability indicates the average homogeneity of the group for the initial assessment, the value being CV=14.193% and an inhomogeneity of the group for the final assessment, the recorded value being CV=24.118%. At the comparative level between the groups, the final mean values for *anterior tilt* difference between the means of the two groups is statistically significant at p<0.025 (independent t = 2.096).

Table no. 1. The initial and final results recorded by the experimental and control groups in the balance test.

	Variable	The experimental group $\bar{x}$±Ds		t dep/p	The control group $\bar{x}$±Ds		t dep/p	tind/p	ω²	DSp	ES
		TI	TF		TI	TF					
Limits of Stability	Anterior tilt (degrees°)	5.017± 1.163	6.922± 1.104	5.673/ p<0.0005	5.686± 0.807	5.809± 1.401	0.43/ p>0.05	2.096/ p<0.025	0.134	1.204	0.924
	Posterior tilt (degrees°)	4.558± 1.103	6.595± 1.06	3.897/ p<0.005	4.279± 0.849	4.74± 0.859	2.125/ p<0.05	4.534/ p<0.01	0.471	0.975	1.903
	Lateral tilt S (degrees°)	6.443± 2.244	9.522± 1.197	4.202/ p<0.005	6.608± 1.479	7.994± 1.22	3.093/ p<0.01	2.95/ p<0.01	0.259	1.207	1.266
	Lateral tilt D (degrees°)	7.63± 1.682	10.067± 1.564	4.142/ p<0.005	7.426± 1.607	8.275± 0.893	1.858/ p<0.05	3.365/ p<0.005	0.319	1.305	1.373

Posterior tilt. In the experimental group, the athletes achieved a mean difference of 2.0370^0 in the *posterior tilt*, from $\bar{x}$±Ds=4.558±1.103^0 during the initial testing, to $\bar{x}$±Ds=6.595±1.06^0 during the final testing. The difference between the means is statistically significant at p<0.005 for t = 3.897, according to the dependent Student's t-test. The coefficient of variability shows us at the initial testing an inhomogeneous group (CV=24.199%), and at the final testing (CV= 16.073%), (Table no. 1, Figure no. 2.). In the control group, in terms of the *posterior tilt* the athletes achieved a mean difference of 0.461^0, from $\bar{x}$±Ds =4.279±0.849^0 during the initial testing, to $\bar{x}$±Ds =4.74±0.859^0 during the final testing. The difference between the means is statistically significant at p<0.05 for t = 2.125, according to the dependent t-test. The coefficient of variability indicates a homogeneity of the collected data (TI-CV= 19.841%, TF-CV= 18.122%). At the comparative level between the groups, in terms of the *posterior tilt*, observed that during the final testing a statistically significant difference of p<0.01 was emphasized, in favor of the experimental group.

Left lateral tilt. In the experimental group it is observed the difference between the two tests, initial and final means of 3.079^0, statistical significance at p<0.005. In the control group, the value of the means recorded for the *left lateral tilt* during the initial testing are $\bar{x}$±Ds=6.608±1.479^0 compared to $\bar{x}$±Ds=7.994±1.22^0 during the final testing (Table no. 1). The difference between the means is by calculating the independent test we obtained a significance threshold of p<0.01 (t= 3.093). The dispersion of the results was inhomogeneous during the initial testing (TI–CV= 22.382%) and relatively homogeneity during the final testing (TF–CV= 15.261%). At the comparative level between the groups, in terms of *left lateral tilt*, the difference between the means of the groups of 11.528^0, $\bar{x}$±Ds=9.522±1.197^0 in the experimental group, and $\bar{x}$±Ds=7.994±1.22^0 in the control group, shows a statistical significance of p < 0.01 for t = 2.95.

Right lateral tilt. The value of the means recorded in the experimental group, for the *right lateral tilt* during the initial testing *was* $\bar{x}$±Ds=7.63±1.682^0, compared to $\bar{x}$±Ds=10.067±1.564^0 during the final testing. Furthermore, by calculating the dependent test, we obtained a significance threshold of p<0.005 (t= 4.142). In

the control group, the results recorded for the *right lateral tilt* increased by 1.792^0, at $\bar{x}$±Ds=$7.426±1.607^0$ during the initial testing, compared to $\bar{x}$±Ds =$8.275±0.893^0$ during the final testing. Calculating the dependent Student's t-test we obtained a significance threshold of $p<0.005$ (t= 1.858). The results are dispersed relatively inhomogenously during the initial testing and relatively homogeneous during the final testing. At a comparative level between the groups, the results recorded for the *right lateral tilt* show that the difference between the means of the experimental group ($\bar{x}$±Ds=$10.067±1.564^0$) and the control group ($\bar{x}$±Ds =$8.275±0.893^0$), during the final testing, is statistically significant at the significance level $p<0.01$ (t= 3.365). The two groups are equal in terms of the degree of homogeneity, and CV% has values between 15,536% and 10,792%, limits corresponding to the qualifier "medium homogeneity".

The effect size for the two scales was calculated and is ES=0.924 for *anterior tilt*, ES=1.903 for *posterior tilt*, ES=1.266 for *left lateral tilt*, ES=1.373 for *right lateral tilt*, which denotes the effectiveness of the program we are recommending. ω^2 reinforces the previous statement that the independent variable positively influences the dependent variable.

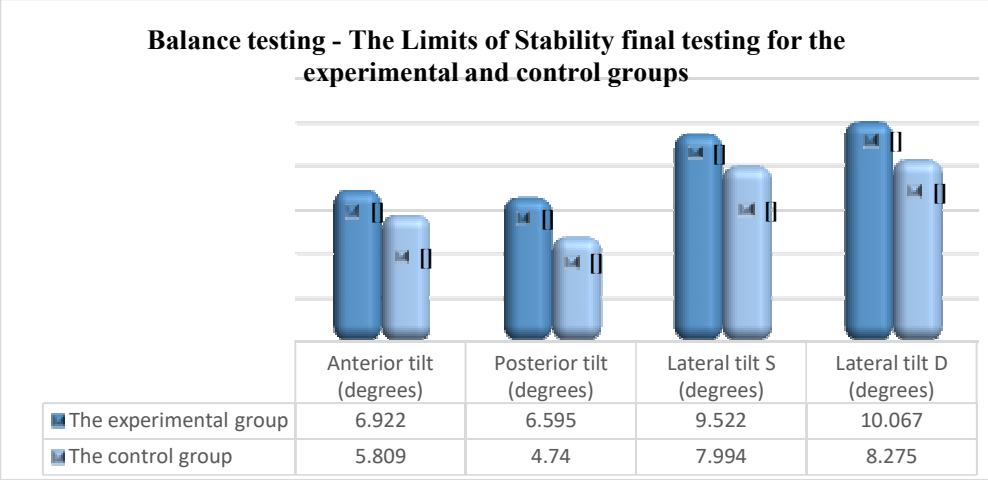

Fig. no. 2. Graphical representation of the balance test – the Limits of Stability, during the final testing for the experimental and control groups

The results obtained during the balance test, the limits of stability had a positive values' evolution, which indicates an improvement in the ankle joint stability, therefore proving that the aquatic prevention and rehabilitation program associated with physical therapy is effective.

Ragab, Mohamed, (2020) compare the effects of the physical therapy program, which contains two ways of performing physical therapy exercises in land-based and aquatic environments, in patients with chronic lateral ankle sprain. All participants, n=40 subjects (30 males and 10 females) are football players. The results of the research showed that participants in both groups, both land-based and aquatic, showed improvements in their ankle's functional ability. Another study by Gioftsidou *et al.* (2013) assessed balance deficits after ankle sprains in students and examined the effectiveness of two different balance rehabilitation programs. Thirty students with functional ankle instability were randomly divided into two groups. Both groups followed a 6-week intervention balance program, 3 times per week, 20 minutes per session, using balance boards. One of the 2 training groups performed the exercises on the ground– the "Land-based" group (n = 15), and the other in the pool – the "Aquatic" group (n = 15). Balance assessments also included testing the limits of stability: anterior-posterior, medial-lateral on the Biodex stability system. The results of the research indicate the fact that performing balance exercises in or out of water by students with functional ankle instability improves their balance ability. They found, as in our study, that the experimental group improved balance.

The study of Mateescu (2010), developed and experimented some training programs through schemes of aquatic and dry land combined contractions in 24 students – men, second year in the Faculty of Physical Education and Sport of Pitesti, aged 18-20 years, divided into two experimental groups (aquatic n = 12 experimental group and dry land n = 12 control group). The autor compared the results of muscle strength development and the experiment showed that the experimental group improved their power indices compared with control group, which used the same dry land-adapted programs, with a value between:2.47 and 8.47%. A study of Pancheva T. G., (2021), used proprioceptive training on postural balance and limb functioning in patients with chronic ankle instability of 15 young individuals diagnosed with chronic ankle instability for 6 months. The proprioceptive training improved both the static and dynamic unilateral balance of patients with unilateral chronic ankle instability like in our study.

The research carried out by Nualona, Piriyaprasartha, Yuktanandana (2013) compares the effect of a 6-week functional rehabilitation program in athletes with chronic ankle instability between the group which performed the physical therapy program in the aquatic environment and the group which performed the program of land-based physical therapy, and it assesses the functional ability of the ankle and the number of relapses. Forty-seven university level athletes with chronic ankle instability and residual symptoms were randomized into a hydrotherapy group (24 participants) and a land-based group (23 participants). All participants were taped using a heel lock technique at the injured ankle during the training session. The rehabilitation program included stretching, aerobic exercise, balance exercise, strengthening exercise, and skill training using an aquatic or land-based environment according to the group for 6 weeks. A single-limb hopping test and ankle joint position sense were measured at baseline, 6 weeks, and 3 months. Recurrent ankle injuries were also recorded. The authors recommended for sports rehabilitation programs combining ankle taping and land-based exercise or hydrotherapy to improve ankle functional performance.

Another study of Zverev, Kurnikova (2016) assess the feasibility of a community-based adapted group aquatic program and its impact on balance in children and adolescents with cerebral palsy (CP). Thirteen children and adolescents participated in a 24-week community-based group aquatic program twice weekly for 45 minutes each session. They found that the training sessions which incorporated swimming and balance challenging tasks of the Functional and Specific Balance Training Program (FSBTP) had a positive and sustainable impact on balance measures of the participants. The findings of our study are consistent with the results of other studies that have also shown that the effects of aquatic interventions improve ankle balance and functional performance.

Conclusions.

The program applied to the experimental group produced improvements in balance in 11-12-year-old soccer athletes with ankle sprains. The results showed that both programs were effective, but the comparison between the level of the evaluated parameters showed higher indices in the experimental group compared to the control group. The comparative analysis between the initial and final testing, in each group, indicates progress in terms of the balance, improving the posture and proving the efficiency of the programs completed by both groups. Only one parameter from the control group did not show statistical significance – the anterior tilt. The comparative analysis between the groups clearly shows that the program developed for and applied to the experimental group produced improvements in the performances of all the assessed parameters and, thus, progress was proven for this group.

The multiple indicators analyzed created an obvious picture of the experimental course, therefore it is proven that the prevention and recovery program applied to football athletes diagnosed with ankle sprain, the Bad Ragaz Ring method, respectively physical therapy on land and in the aquatic environment, with technical elements specific to the game of football have led to significant improvements. The program might be considered to augment the rehabilitation process to improve the ankle's function of football athletes with ankle sprain.

Conflicts of interest - The authors have no conflicts of interest to declare.

References

Anandacoomarasamy A, Barnsley L., (2005). Long term outcomes of inversion ankle injuries. *Br J Sports Med*. ;39(Suppl 3): e14–e1e. doi: 10.1136/bjsm.2004.01167

Bihter, A., Kocahan, T., (2015). Associations Between Measures of Balance and Lower-Extremity Muscle Strength/Power in Healthy Individuals Across the Lifespan: A Systematic Review and Meta-Analysis, *Sports Med*. 2015; 45(12): 1671–1692.

Buckthorpe M., Pirotti E., Villa F.D., (2019). Benefits and use of aquatic therapy during rehabilitation after acl reconstruction -a clinical commentary. Int *J Sports Phys Ther*. 2019 Dec;14(6):978-993. PMID: 31803530; PMCID: PMC6878863.

Cooke MW, Marsh JL, Clark M, Nakash R, Jarvis RM, Hutton JL, Szczepura A, Wilson S, Lamb SE., (2009). Treatment of severe ankle sprain: a pragmatic randomized controlled trial comparing the clinical effectiveness and cost-effectiveness of three types of mechanical ankle support with tubular bandage. The CAST trial. Health Technol Assess.;13 (Suppl 13), 1-121.

Cooke MW, Lamb SE, Marsh J, Dale J., (2003). A survey of current consultant practice of treatment of severe ankle sprains in emergency departments in the United Kingdom. Emerg Med J.;20(6):505-7. Epub /11/19.

Coraci D., Tognolo L., Maccarone M.C., Santilli G., Ronconi G., Masiero S., (2022). Water-Based Rehabilitation in the Elderly: Data Science Approach to Support the Conduction of a Scoping Review., *Appl. Sci*.2022,12,8999, https://doi.org/10.3390/app12188999

Edvardsson, A., Ivarsson, A., Johnson, U., (2012). Is a cognitive-behavioural biofeedback intervention useful to reduce injury risk in junior football players? *Journal of Sports Science and Medicine* 11, 331-338. http://www.jssm.org

Eunkuk K., Hokyung C., (2014). Aquatic Physical Therapy in the Rehabilitation of Athletic Injuries: A Systematic Review of the Literatures, *Journal of Yoga & Physical Therapy*, DOI: 10.4172/2157-7595.1000195.

Gianfaldoni et al., (2017). History of the Baths and Thermal Medicine, Open Access Macedonian *Journal of Medical Sciences*, 5 (4), 566-568.

Gioftsidou A., Malliou P., Godolias G., Sofokleous P., Beneka A., Tsapralis K., (2013). Aquatic Training for Ankle Instability, Foot Ankle Spec 2013, 6: 346 originally published online 27 June 2013, https://journals.sagepub.com/doi/10.1177/1938640013493461

Hägglund, M., Waldén, M. and Ekstrand, J., (2009). Injuries among male and female elite football players. Scandinavian Journal of Medicine and Science in Sports, 19, 819-827.

Halabchi, F., Hassabi, M., (2020). Acute ankle sprain in athletes: Clinical aspects and algorithmic approach World *J Orthop* ,2020 December 18; 11(12): 534-558 DOI: 10.5312/wjov11i12.534

Harrison RA, Allard LL. An Attempt to Quantify the Resistances Produced Using the Bad Ragaz Ring Method. Physiotherapy 1982; 68: 330-331.

Herzog, M.M, Kerr, Z., Marshall, S.W., Wikstrom, E.A., (2019). Epidemiology of Ankle Sprains and Chronic Ankle Instability Journal of Athletic Training;54(6):603–610 doi: 10.4085/1062-6050-447-17

Johansson J., Jarocka E., Westling G., Nordström A., Nordström P., (2019). Predicting incident falls: Relationship between postural sway and limits of stability in older adults, *Human Movement Science*, Elsevier, Volume 66, August 2019, Pages 117-123

Juras G., Słomka K., Fredyk A., Sobota G., Bacik B., (2008). "Evaluation of the Limits of Stability (LOS) Balance Test". *Journal of Human Kinetics*. 19, 39–52. doi:10.2478/v10078-008-0003

Kemler E, van de Port I, Valkenberg H, Hoes AW, Backx FJ., (2015). Ankle injuries in the Netherlands: trends over 10-25 years. Scand J Med Sci Sports.; 25(Suppl 3):331–7

Kevin, E., David, M., J., (2013). The Use of Aquatics in Orthopedic and Sports Medicine Rehabilitation and Physical Conditioning, Slack Incorporated, p. 37.

Mateescu A., (2010). Study on the effects of aquatic vs. dry land combined contractions on muscle strength for the students in physical education and sport, *Journal of Physical Education and Sport* Vol 27, no 2, June, 2010

Melanson S.W., Shuman V.L., (2023). *Acute Ankle Sprain*, StatPearls Publishing; 2023 Jan., https://www.ncbi.nlm.nih.gov/books/NBK459212

Nualon P., Priryapasarth P., Yuktanandana P., (2013). The role of 6-week hydrotherapy and land-based therapy plus ankle taping in a preseason rehabilitation program for athletes with chronic ankle instability., *Asian Biomedicine* 7: 553-559.

Pancheva T. G., (2021). Effect of proprioceptive training on postural balance in patients with chronic ankle instability, *Journal of Physical Education and Sport* ® (JPES), Vol. 21 (1), Art 1, pp. 3 – 11

Polzer, H., Kanz, K.G., Prall, W.C., Haasters, F., Ockert, B., Mutschler, W., Grote, S., (2012). Diagnosis and treatment of acute ankle injuries: development of an evidence-based algorithm. *Orthop Rev* (Pavia); 4: e5 PMID: 22577506 DOI: 10.4081/or2012.e5. Epub.

Ragab I. M., Mohamed N. A., (2020). Aquatic Therapy Versus Combined Aquatic and LandBased Therapy in the Treatment of Chronic Lateral AnkleSprain, June 2020, *Egyptian Journal of Physical Therapy* 2(1):16-23, DOI:10.21608/ejpt.2020.32561.1008

Ristolainen, L., Heinonen, A., Waller, B., Kujala, U. M. and Kettunen, J. A., (2009). Gender differences in sport injury risk and types of injuries: A retrospective twelve-month study on cross-country skiers, swimmers, long-distance runners and soccer players. *Journal of Sports Science and Medicine*, 8(3), 443-451.

Simion, Gh., (1998). *The methodology of researching human activity in motion [Metodologia cercetării activităţii omului în mişcare*], Edit. University of Piteşti, p. 233

Thomas, J.R., Nelson, J. K., (1990). *Research in Physical Activity*, Second Edition, Champaign, Illinois, Human Kinetics Books.

So B.C.L., Ng J.K., Au K.C.K., (2019). A 4-week community aquatic physiotherapy program with Ai Chi or Bad Ragaz Ring Method improves disability and trunk muscle endurance in adults with chronic low back pain: A pilot study. *J Back Musculoskelet Rehabil*. 2019;32(5):755-767. doi: 10.3233/BMR-171059. PMID: 30689551.

Thompson, J. Y., Byrne, C., Williams, M.A., Keene, D. J., Schlussel, M. M., Lamb, S. E., (2017). Prognostic factors for recovery following acute lateral ankle ligament sprain: a systematic review, *BMC Musculoskeletal Disorders* 18:421 DOI 10.1186/s12891-017-1777-9.

Vuurberg, G., Hoorntje, A., Wink, L. M., Doelen, B. F. W., van der, Bekerom, M. P., van den Dekker, R., et al., (2018). Diagnosis, treatment and prevention of ankle sprains: update of an evidence-based clinical guideline. Br. *J. Sports Med*. 52, 956–956. doi: 10.1136/bjsports-2017-098106

Zverev Y., Kurnikova M., (2016). Adapted community-based group aquatic program for developing balance: a pilot intervention study involving children and adolescents with cerebral palsy, *Journal of Physical Education and Sport* ® (JPES), 16(4), Art 200, pp. 1258 – 1265