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Range of motion (ROM) and Dynamic Balance Testing through Kinetic Prophylaxis Means (Applying *Tissue Flossing*) to Football Players

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Abstract: *Background. An individual's ankle range of motion varies dependent on their ADLs, geographic region, and amount of physical activity. Walking, which takes 30 degrees of movement, and descending stairs, which requires 57 degrees, do not need a large ROM.*
Hypothesis. We hypothesised that a floss band (F.B.) placed on the ankle joint of football players of any age in conjunction with a kinetic prophylactic exercise program would enhance range of motion (ROM) and dynamic balance to a higher degree than a simple kinetic prophylactic exercise program (without F.B. application).
Aims. This study aims to examine the impact of a floss band on the range of motion (ROM) and dynamic balance at the ankle joint, measure the ankle joint mobility and balance of football players, and maybe identify individuals susceptible to injury.
Methods. The current study comprised 18 participants (mean age = 19.77 years) who were all football players from the academy and club of FK Csikszereda Miercurea Ciuc. The participants were evenly split into two groups: an experimental group and a control group.
Results. Based on the data retrieved from this research, we can conclude that Floss Band treatment combined with exercise improves range of motion and dynamic balance, although not statistically significant on the majority of criteria.
Conclusions. When paired with a kinetic training program, the floss band kinetic prophylactic approach significantly improves range of motion and dynamic balance, hence contributing to injury prevention.

Keywords: *Range of motion; Tissue flossing; Prophylaxis; Dynamic balance; Football players.*

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Introduction

An individual's ankle range of motion varies based on their ADLs (Activities of Daily Living), geographic location, and level of physical activity. A high ROM is not necessary for daily tasks, such as walking, which needs 30 degrees of movement and descending stairs, which requires 57 degrees (Cho et al., 2016; Fong et al., 2011; Gates et al., 2016; Jung et al., 2021).

Around a mediolateral axis, plantar flexion happens in a sagittal plane. Normal plantarflexion range of motion (ROM) in adults varies between 45 and 55 degrees. Walking, running, leaping, cycling, and depressing the gas pedal are everyday actions that involve plantar flexion. The soleus muscle, medial gastrocnemius, and lateral gastrocnemius are responsible for plantar flexion at the ankle joint, with assistance from the posterior tibialis, long and short flexor hallucis, and short flexor digitorum (Alves et al., 2019; Kim & Kim, 2019; Guillén-Rogel et al., 2017).

Insufficient plantar flexion inhibits the production of adequate force when walking or running. This results in diminished agility and propulsion among athletes, including football players. Reduced plantar flexion is associated with knee, hip, and even back pain due to constrained biomechanics. Any injury to the muscles responsible for plantar flexion will reduce this joint's range of motion. Ankle injuries (sprains, dislocations, fractures), contractures, and musculoskeletal deterioration are other causes of decreased plantar flexion (Brockett & Chapman, 2016; Chinn et al., 2010; Halperin et al., 2014; Hyodo et al., 2017; Ness et al., 2018; Suga et al., 2021).

Around a mediolateral axis, dorsiflexion happens in a sagittal plane. In a non-supine posture, the typical range of motion for dorsiflexion in adults varies between 15 and 20 degrees. Multiple variables influence these values. The degree of dorsiflexion measured with the knee flexed may be larger than when the knee is extended. In a weight-bearing posture, such as orthostasis, the recorded dorsiflexion is comparable to that measured in a weight-bearing position (Basnett et al., 2013; Hernández-Guillén et al., 2021; Hoch et al., 2015; Young et al., 2013).

Football is now one of the most physically demanding sports activities, and it has a high rate of players becoming injured (Walls et al., 2016). The players' honesty and physical well-being are of the utmost significance since football is the world's most watched and costly sport. Participation in this sport, which requires a significant amount of physical effort and leaves little time for the body to return to its original parameters after that effort, significantly increases the risk of injury, with ankle injuries being the most common and having a relatively high incidence. They are responsible for one-third of all accidents' injuries (Halabchi et al., 2020; Kolokotsios et al., 2021).

Compared to other sports, football is among the most vigorous sports with a high incidence of injuries. The sport involves complex movements such as sudden acceleration and deceleration, pivots and sharp turns (Manoel et al., 2020; Woods et al., 2003).

In order to decrease the number of injuries, prevent early withdrawal from the sport, and prepare athletes for competitive situations, it is of utmost importance to include prevention programmes in the training plan. A properly structured and implemented prevention programme maintains the integrity of football players, reduces the costs of treatment or hospitalisation and enhances the performance of athletes (Rahnama, 2011).

In Starrett and Cordoza's book "Becoming a supple leopard," released in the United States in 2013, the concept of medical flossing was introduced and publicised for the

first time. Medical flossing is a relatively recent therapeutic practice. The use of latex or rubber tape to muscles, joints, or other soft tissues for one to three minutes is known as flossing tape treatment. The tape has a thickness of 1–2 millimetres, varies in length, and is elastic. Because it is made of latex, it exerts a significant amount of cohesive force on the skin (Ahlhorn, 2015).

Tissue flossing has been shown to reduce the risk of injury while exercising and boost athletic performance (Konrad et al., 2017). Floss bands, often known as FLOSS, are an innovative device that may increase joint range of motion (Driller et al., 2017a, 2017b) or lessen discomfort (García-Luna et al., 2020). They may be used before or after athletic competition to avoid injuries or aid recovery. FLOSS is a form of an elastic band made of rubber that may be wrapped around joints or muscle groups to facilitate training or stretching. This band was developed by physical therapist Kelly Starrett (Kiefer et al., 2017; Wu et al., 2022).

The primary benefits of a floss band are the enhancement of the range of motion (ROM), the reduction of discomfort and oedema, the prevention of injuries, and the acceleration of an athlete's return to competition.

According to the research that has been done, there are typically three steps involved in preventative medicine (Katz & Ali, 2009; Leavell & Clark, 1965). The eradication of disease causes is the focus of primary preventive efforts, which are undertaken to forestall the development of the disease state. In secondary prevention, the target is the disease itself, and the goal is to interfere with the progression of the illness before any symptoms manifest. In the last stage of disease prevention, tertiary prevention, the emphasis is on containment to reduce the harmful effects of a symptomatic condition on the body and society (Hewett & Bates, 2017).

Rehabilitation is one method that may be used to address secondary prevention (Hewett & Bates, 2017; Cools et al., 2020). There are various particulars to consider at this stage of the care of sports injuries. Its purpose is to orient and lead the wounded tissue's healing process, restore function, and assist the patient or athlete in returning to their athletic activity while simultaneously reducing the chance of sustaining a second injury. This multi-goal management is handled mostly via biological and physical components (such as physiological and biomechanical aspects). However, psychological, social, and environmental aspects are essential in rehabilitating patients and athletes after a sports injury. These elements should be considered throughout this phase of the therapy of sports injuries (Edouard & Ford, 2020; Hewett & Bates, 2017).

Primary kinetic prophylaxis programmes are applied for modifiable factors, such as muscle imbalances, muscle weakness, incorrect biomechanics or poor joint mobility. With screening programmes carried out regularly, problems of this kind can be discovered and removed early.

This research aims to *emphasise the significance of primary kinetic prophylaxis programs for competitive and elite youth athletes*. Through prevention, a player's health is preserved, their athletic performance is maximised, and hospitalisation expenses are reduced.

As novelty aspects of the current work, *the significance of kinetic-prophylactic workouts in football may be noted, as they provide players with the necessary physical integrity and the longest possible career without injury*. In addition, we may emphasise kinetic prophylactic measures, such as medical flossing, in this circumstance. *Floss tape is considered a relatively new therapeutic method*; the number of studies in this field is still limited, so the purpose of the present study was *to collect new relevant data and investigate the effects of this kinetic prophylactic method, specifically, to what extent can this tape improve ankle joint range of motion?*

Material and methods

Research Hypothesis

In this research, we started from the *hypothesis* that the therapeutic medium, floss band (F.B.), applied to the ankle joint of football players, regardless of age, combined with a kinetic prophylactic exercise program improves both ROM and dynamic balance to a greater extent than a simple kinetic prophylactic exercise program (without F.B. application).

Research Objective

The research's overall objective was to determine *the effect of the floss band on ROM and dynamic balance at the ankle joint*, *to assess the ankle joint mobility and balance of football players and possibly filter out those prone to injury*.

The research was conducted over four weeks, from March 14, 2022, to April 8, 2022.

Location of the research: the Székelyföldi Labdarúgó Akadémia Football Academy in Miercurea Ciuc.

The present research included 18 subjects (mean age = 19.77 years), all football players of the academy and the football team FK Csíkszereda Miercurea Ciuc, who were equally divided into two groups: an experimental group and a control group. Both groups followed a similar kinetic program consisting of 5 exercises (dorsal flexion, plantar flexion, circumduction, two-legged jumps and single-legged jumps), the only difference being that for the subjects of the experimental group, the floss tape was applied twice a week for four weeks.

The subjects were divided: nine players made up of the experimental group and nine in the control group. The players in the experimental group were given the kinetic prophylactic medium, the floss band, and a kinetic prophylactic exercise program, while only the kinetic prophylactic exercise program was implemented for the players in the control group.

The floss band application for the experimental group was carried out as follows: to one person, the therapeutic medium was applied twice, one after the other, each application lasting approximately 2 minutes. The applications were repeated twice weekly for one month (4 weeks). A transparent plastic goniometer was used to measure ROM. The subjects were tested from a supine position on a bed with the knee extended, i.e., from a non-supporting position with the leg hanging down. The centre of the goniometer was placed under the lateral malleolus, on the joint, with the fixed arm following the head of the fibula and the mobile arm moving parallel to the V metatarsal. Range of motion was measured in both ankle joints.

Dynamic balance was tested using professionally functional equipment called Y-Balance Test Kit (YBT), developed from the Star Excursion Balance Test (SEBT). YBT is composed of fewer directions of travel than SEBT.

The Y-Balance Test Kit is a measuring instrument consisting of a platform from which three numbered pipes emerge like a roulette wheel. These pipes extend in three directions: anterior (Anterior Reach), postero-lateral (Postero-Lateral Reach) and posteromedial (Postero-Medial Reach), with a wooden plate on them that slides and measures the distance reached. Subjects had to place the tested leg on the platform and

extend the contralateral leg as far as possible, returning to the original position without losing balance.

Correct execution of the measurement was recorded if it met the following rules:

- The test subject had their hands placed at their hips during executions;
- The test subject maintained balance during the executions without placing the leg flat on the ground;
- The heel of the support leg did not lift off the platform;
- The toes of the support leg did not cross the red line on the platform;
- No body weight was placed on the outstretched leg during the executions;
- The wooden board was gently stretched with the toes of the tested foot without being pushed.

Two measurements were recorded for each leg, in each direction, and the larger of the two trials were added to the results.

Software used: Microsoft Office—Microsoft Word, Microsoft Excel
Equipment used:

- Sanctband CompreFloss floss band Blueberry (medium);
- Goniometer;
- FMS Y-Balance Test Kit.

The multidisciplinary team comprised sports doctors, physiotherapists, and physical trainers.

We want to mention that all 18 football players in this study consented to participate in this research. The managers of the academy and the AFK Csíkszereda Miercurea Ciuc team agreed to the research.

Applied Kinetic Prophylactic Program

The kinetic prophylactic program was a standardised, uniform one for both batches. Five exercises were introduced in this programme. The structure of the programme for the experimental group was as follows:

- In each person, the floss band was applied two times, one after the other on one ankle, with a minimal break between applications, each use lasting approximately 2 minutes, after which the band was also applied to the contralateral ankle;
- A floss band was applied to the ankle joint, starting at the distal part of the foot and extending to the distal part of the tibia;
- The band was applied at 50% stretch, each layer overlapping the previous one by approximately 50%;
- After applying the band, subjects were asked to perform those five exercises (described below);
- After performing the exercises, the band was lowered for 1 minute, an interval of time when subjects performed some maximum dorsi- and plantarflexion to restart blood circulation;
- After the given break, the second application was performed.

For the control group, the order and dosage of exercises were the same. The control group also performed the same number of repetitions twice after the other, with a minimum break of about 1 minute. The frequency of sessions was the same as that of the experimental group: 2 per week for four weeks.

The only difference between the two groups in the execution of the exercises was that in the control group, the dorsal flexion, plantar flexion and circumduction were performed simultaneously with both legs. In contrast, in the experimental group, they were performed sequentially.

Kinetic Prophylactic Program Exercises

Exercise 1—*dorsiflexion*. From the initial supine position on the bed, with the knees extended and the leg hanging off the edge of the bed, maximum dorsal flexion was performed. Subjects maintained the position at maximum for 1–2 seconds. The prescribed dosage was 20 repetitions per two sets.

Exercise 2—*plantarflexion*. From the initial supine position on the bed, knees extended, leg hanging off the edge of the bed, maximum plantarflexion was performed. Subjects maintained the position at the maximum point for 1–2 seconds. The prescribed dosage was 20 repetitions per two series.

Exercise 3—*circumduction*. From the initial supine position on the bed, knees extended, leg hanging off the edge of the bed, circumduction of the ankle joint was performed. The prescribed dosage was 20 repetitions over two series.

Exercise 4—*two-legged jumps*. Small jumps were performed on the spot from two legs from the initial orthostatic position with the legs shoulder-width apart. The prescribed dosage was 30 seconds per two sets.

Exercise 5—*single-legged jumps*. Small single-legged jumps were performed on the spot from the initial orthostatic position with legs shoulder-width apart. The prescribed dosage was all 30 seconds for two sets. After 30 seconds of jumping on one leg, subjects also performed the exercise on the contralateral leg.

The study was granted permission to proceed by the medical ethics committee of the George Emil Palade University of Medicine, Pharmacy, Science and Technology (UMFST) (Resolution No. nr. 1624 from 24.02.2022), and all of the procedures were carried out following the requirements outlined in the Helsinki Declaration.

Results

This research included eight football players from the academy and the football club FK Csíkszereda Miercurea Ciuc. All research subjects followed a standardised kinetic prophylactic exercise program. The first group, the control group, followed only the prescribed exercises. The second group, the experimental one, in addition to the kinetic prophylactic program, also benefited from applying a therapeutic method, the floss band, for four weeks.

Table I. ROM measurement results of the experiment group

Subjects	Age	ROM initial right ankle		ROM final right ankle		ROM initial right ankle		ROM final right ankle	
		PF	**DF**	**PF**	**DF**	**PF**	**DF**	**PF**	**DF**
Cs.B.	23	45°	16°	52°	20°	51°	18°	59°	19°
A.Sz.	27	46°	19°	58°	24°	46°	16°	50°	24°
B.M.	18	44°	10°	49°	14°	48°	16°	49°	18°
K.M.	18	32°	18°	40°	24°	42°	20°	52°	30°
H.T.	18	40°	18°	54°	26°	40°	20°	38°	20°
S.B.	18	38°	15°	40°	15°	40°	14°	42°	21°
B.T.	18	40°	20°	43°	30°	42°	22°	45°	30°
D.B.	18	41°	20°	55°	21°	40°	19°	40°	26°
N.B.	18	40°	15°	40°	28°	38°	15°	38°	30°

* PF = Plantar flexion, **DF = Dorsi flexion
Source: Author's own conception

Table II. ROM measurement results of the control group

Subjects	Age	ROM initial right ankle		ROM final right ankle		ROM initial right ankle		ROM final right ankle	
		PF	**DF**	**PF**	**DF**	**PF**	**DF**	**PF**	**DF**
A.C.	26	36°	19°	35°	19	51°	17°	49°	19°
T.Á.	18	44°	10°	45°	12°	40°	10°	37°	10°
S.R.	18	34°	20°	38°	15°	30°	17°	32°	12°
Sz.Sz.	18	44°	20°	48°	26°	42°	24°	44°	28°
M.N.	18	32°	14°	44°	19°	32°	11°	38°	10°
Sz.A.	18	26°	14°	34°	14°	32°	10°	30°	10°
B.L	21	37°	21°	35°	17°	37°	20°	34°	20°
J.R.	24	43°	22°	44°	19°	40°	20°	43°	18°
G.B.	19	36°	11°	40°	10°	28°	10°	28°	9°

* PF = Plantar flexion, **DF = Dorsi flexion
Source: Author's own conception

Table III. Y Balance test results of the experiment group

Subjects	Anterior Right (cm)		Anterior Left (cm)		Postero-Lateral Right (cm)		Postero-Medial Right (cm)		Postero-Lateral Left (cm)		Postero-Medial Left (cm)	
	initial	**final**	**initial**	**final**	**initial**	**final**	**initial**	**final**	**initial**	**final**	**initial**	**final**
Cs.B.	45	50	50	50	105	106	105	106	106	112	96	113
A.Sz.	65	67	68	68	120	121	120	127	122	121	119	120
B.M.	65	68	62	66	115	116	109	109	110	117	117	117
K.M.	64	62	65	65	119	119	112	118	108	114	106	109
H.T.	53	58	52	58	102	108	101	102	99	116	97	107
S.B.	52	54	54	59	114	111	106	106	111	113	101	109
B.T.	60	64	61	65	111	113	115	116	115	112	106	112
D.B.	56	59	59	65	99	98	92	94	102	106	90	96
N.B.	52	59	58	63	103	111	103	97	100	108	97	106

Source: Author's own conception

Table IV. Y Balance test results of the control group

Subjects	Anterior Right (cm)		Anterior Left (cm)		Postero-Lateral Right (cm)		Postero-Medial Right (cm)		Postero-Lateral Left (cm)		Postero-Medial Left (cm)	
	initial	**final**	**initial**	**final**	**initial**	**final**	**initial**	**final**	**initial**	**final**	**initial**	**final**
A.C.	65	64	60	59	110	111	110	111	111	112	105	104
T.Á.	43	44	64	67	102	101	104	101	104	103	102	99
S.R.	61	65	64	64	110	109	117	110	117	106	126	102
Sz.Sz.	55	59	51	54	103	104	106	109	108	108	108	107
M.N.	62	63	60	60	114	104	114	100	115	104	113	103
Sz.A.	52	49	52	48	105	107	108	100	108	102	104	102
B.L	59	61	53	53	107	110	110	108	111	112	104	105
J.R.	62	64	51	52	114	109	111	110	113	115	109	106
G.B.	61	61	62	62	115	115	114	110	117	114	108	110

Source: Author's own conception

Statistical analysis

The statistical analysis included elements of descriptive statistics (mean, median, standard deviation) and elements of inferential statistics. The Shapiro-Wilk test was applied to determine the distribution of the data series analysed. For comparison of means, the t-Student test was applied for unpaired data. Mann-Whitney test was applied for comparison of medians for unpaired data (Table V). The significance threshold chosen for the p-value was 0.05. Statistical analysis was carried out using the GraphPad Prism utility trial version.

Table V. Statistical results

		Values	Minimum	Median	Maximum	Mean	St. Deviation	Test	P-value
Anterior right initial	Experiment group	9	45,00	56,00	65,00	56,89	7,044	Unpaired t-test	0,7888
	Control Group	9	43,00	61,00	65,00	57,78	6,797		
Anterior right final	Experiment group	9	50,00	59,00	68,00	60,11	5,862	Unpaired t-test	0,9999
	Control Group	9	44,00	61,00	65,00	58,89	7,373		
Anterior left initial	Experiment group	9	50,00	59,00	68,00	58,78	5,974	Unpaired t-test	0,6323
	Control Group	9	51,00	60,00	64,00	57,44	5,615		
Anterior left final	Experiment group	9	50,00	65,00	68,00	55,78	5,578	Unpaired t-test	0,1315
	Control Group	9	48,00	59,00	67,00	62,65	6,265		
Postero lateral right initial	Experiment group	9	99,00	111,00	120,00	109,8	7,759	Unpaired t-test	0,7752
	Control Group	9	102,00	110,00	115,00	108,9	4,910		
Postero lateral right final	Experiment group	9	98,00	111,00	121,00	111,4	7,020	Unpaired t-test	0,1992
	Control Group	9	101,00	109,00	115,00	107,8	4,265		

Postero lateral left initial	Experiment group	9	99,00	108,00	122,00	108,1	7,441	Unpaired t-test	0,2499
	Control Group	9	104,00	111,00	117,00	111,6	4,419		
Postero lateral left final	Experiment group	9	106,00	113,00	121,00	113,2	4,549	Unpaired t-test	**0,0489**
	Control Group	9	102,00	108,00	115,00	108,4	4,953		
Postero medial right initial	Experiment group	9	92,00	106,00	120,00	107,0	8,246	Unpaired t-test	0,2790
	Control Group	9	104,00	110,00	117,00	110,4	4,126		
Postero medial right final	Experiment group	9	94,00	106,00	127,00	108,3	10,52	Mann Whitney test	0,9647
	Control Group	9	100,00	109,00	111,00	106,6	4,746		
Postero medial left initial	Experiment group	9	90,00	101,00	119,00	103,2	9,770	Mann Whitney test	0,1573
	Control Group	9	102,00	108,00	126,00	108,8	7,259		
Postero medial left final	Experiment group	9	96,00	109,00	120,00	109,9	6,936	Unpaired t-test	**0,0411**
	Control Group	9	99,00	104,00	110,00	104,2	3,232		

Source: Author's own conception

Discussions

According to the data we extracted from this study, we can state that floss band therapy applied in conjunction with exercises improves ROM and dynamic balance more, but not to a statistically significant extent. We had subjects whose final measurements showed improvements over the initial measurements, but these were statistically significant only in the Y Balance test, Postero-Lateral and Postero-Medial final measurements on the left lower limb.

Comparable to this paper, several international studies debate the same topic as ours. These we will describe in more detail below. As medical flossing is a relatively new form of therapy, study results and expert opinions are divided. Preliminary studies suggest positive findings, but further research is needed.

Most existing studies on the subject have similar results to this paper. A similar study by Pakarklis and Siupsinskas (2018) evaluated the instant effects of floss tape on handball players. They measured ROM and dynamic balance before and after tape application. They reported minimal improvement in the ankle dorsiflexion of subjects in the experimental group, but dorsiflexion was also improved in subjects in the control group. In the Y-Balance test, the Anterior Reach test did not change.

Stevenson et al. studied five male athletes measuring ankle ROM pre- and post-floss band application. Only dorsiflexion improved significantly (Stevenson et al., 2016).

The study published by Kaneda et al. produced identical results. They compared the effect of the floss band with static stretching of the gastrocnemius muscle. Dorsiflexion of the experimental group showed an increase after application of the floss band, in contrast to the control group, who performed only static stretching (Kaneda et al., 2020).

Driller and Overmayer (2016) also highlight the importance of floss bands in preventing injury and enhancing athletic performance. Their study included 52 physically active individuals. They measured plantar flexion, dorsal flexion and jumping performance (Single Leg Jump test) pre- and post-floss band application. They received partially positive results: all three measurements improved after only one application, but no significant difference was identified between the control and experimental groups.

Further partially positive results were supported by the work of Vogrin et al. (2020). The study concluded that plantar flexion and dorsal flexion improved after floss tape application to a moderate extent but without statistical significance. Mills also reached this conclusion (2020): the results suggest minimal improvements among rugby players after floss band application to the ankle joint. The sprinting, sprinting and jumping in place tests were improved to a minimal, statistically insignificant extent between the control and experimental groups.

Other studies also debate floss tape's effect on the lower limb. Cheatham (2020), Kaneda (2020), Chang (2021), and Maust (2021) have followed the effects of a floss band applied to the thigh. Cheatham et al. reported a significant increase in passive knee flexion ROM, as did Chang, who demonstrated that the floss band on the thigh significantly improved

quadriceps and hamstring muscle flexibility. Studies by Kaneda (2020) and Maust (2021) concluded that the flexibility of the hamstring muscle group improved after flossing, in contrast to the control group

A possible mechanism for improving joint range of motion and muscle flexibility after floss tape use may be the thixotropic effect and increased muscle stretch tolerance (Kaneda et al., 2020; Konrad et al., 2021).

There are two scientific theories describing the effects of these compressive interventions. This compressive application may provide a "deformation" of the myofascial tissues, creating a mechanical and neurophysiological effect. For the mechanical effect, *the floss tape's tension can modify the fasciae's viscoelastic properties*: thixotropy changes (viscosity decreases), fascial restrictions are reduced, and cellular responses are induced. These changes can be observed as increased muscle stretch tolerance, also leading to changes in joint ROM (Kelly & Beardsley, 2016). For the neurophysiological effect, *floss band tension can induce local or global neurophysiological effects that influence the relaxation of targeted tissues through afferent central nervous system inputs* from mechanoreceptors and Golgi tendon organs (Aboodarda et al., 2015).

Conclusions

1. Summing up, all that has been written and quantified, we can state that *the floss band kinetic prophylactic method improves range of motion and dynamic balance to a greater extent and therefore contributes to injury prevention if combined with a kinetic exercise programme*.

2. Even though we obtained statistically significant results only for Postero lateral left end (p=0.0489) and Postero medial left end (P=0.0411), in terms of the range of motion (ROM) and dynamic balance, we can state with certainty that *the floss band is safe and easy to use by performance athletes or elite juniors*.

Conflict of interests

Nothing to declare.

References

Aboodarda, S. J., Spence, A. J., & Button, D. C. (2015). Pain pressure threshold of a muscle tender spot increases following local and non-local rolling massage. *BMC Musculoskeletal Disorders, 16*, 265. https://doi.org/10.1186/s12891-015-0729-5

Ahlhorn, A. (2015). Schmerzfrei und beweglich durch Abbinden – Medical Flossing. *Physiopraxis*, *13*(09), 35–37. https://doi.org/10.1055/s-0035-1564471

Alves, C., Lysenko, M., Tomlinson, G. A., Donovan, J., Narayanan, U. G., Feldman, B. M., & Wright, J. G. (2019). Plantar flexion, dorsiflexion, range of movement and hindfoot deviation are important determinants of foot function in children. *Journal of Children's Orthopaedics*, *13*(5), 486–499. https://doi.org/10.1302/1863-2548.13.190062

Basnett, C. R., Hanish, M. J., Wheeler, T. J., Miriovsky, D. J., Danielson, E. L., Barr, J. B., & Grindstaff, T. L. (2013). Ankle dorsiflexion range of motion influences dynamic balance in individuals with chronic ankle instability. *International Journal of Sports Physical Therapy*, *8*(2), 121–128.

Brockett, C. L., & Chapman, G. J. (2016). Biomechanics of the ankle. *Orthop Trauma*, 30(3), 232–238. https://doi.org/10.1016/j.mporth.2016.04.015

Chang, N. J., Hung, W. C., Lee, C. L., Chang, W. D., & Wu, B. H. (2021). Effects of a Single Session of Floss Band Intervention on Flexibility of Thigh, Knee Joint Proprioception, Muscle Force Output, and Dynamic Balance in Young Adults. *Applied Sciences*, *11*(24), 12052. https://doi.org/10.3390/app112412052

Cheatham, S.W., Martinez, R. E., Montalvo, A., Odai, M., Echeverry, S., Robinson, B., Bailum, E., Viecco, K., Keller, K., Nunez-Riveria, S., & Pena, A. (2020). Myofascial compression interventions: comparison of roller massage, instrumentassisted soft-tissue mobilisation, and floss band on passiveknee motion among inexperienced individuals. *Clinical Practice in Athletic Training, 3*(3), 24–36.

Chinn, L., & Hertel, J. (2010). Rehabilitation of ankle and foot injuries in athletes. *Clinical Journal of Sport Medicine*, *29*(1), 157–167. https://doi.org/10.1016/j.csm.2009.09.006

Cho, K. H., Jeon, Y., & Lee, H. (2016). Range of Motion of the Ankle According to Pushing Force, Gender and Knee Position. *Annals of Rehabilitation Medicine*, *40*(2), 271–278. d https://doi.org/10.5535/arm.2016.40.2.271

Cools, A. M., Maenhout, A. G., Vanderstukken, F., Declève, P., Johansson, F. R., & Borms, D. (2021). The challenge of the sporting shoulder: From injury prevention through sport-specific rehabilitation toward return to play. *Annals of Physical and Rehabilitation Medicine, 64*(4), 101384. https://doi.org/10.1016/j.rehab.2020.03.009

Driller, M. & Overmayer, R. (2016). The effects of tissue flossing on ankle range of motion and jump performance. *Physical Therapy in Sport, 28*, 29-33. https://doi.org/10.1016/j.ptsp.2017.08.081

Driller, M., Mackay, K., Mills, B., Tavares, F. (2017a). Tissue flossing on ankle range of motion, jump and sprint performance: A follow-up study. *Physical Therapy in Sport*, 28, 29-33. https://doi.org/10.1016/j.ptsp.2017.08.081

Driller, M.W., & Overmayer, R. G. (2017b). The effects of tissue flossing on ankle range of motion and jump performance. *Physical Therapy in Sport*, *25*, 20-24. https://doi.org/10.1016/j.ptsp.2016.12.004

Edouard, P., & Ford, K. R. (2020). Great Challenges Toward Sports Injury Prevention and Rehabilitation. *Front Sports Act Living*, *2*, 80. https://doi.org/10.3389/fspor.2020.00080

Fong, C. M., Blackburn, J. T., Norcross, M. F., McGrath, M., & Padua, D.A. (2011). Ankle-dorsiflexion range of motion and landing biomechanics. *Journal of Athletic Training*, *46*(1), 5–10. https://doi.org/10.4085/1062-6050-46.1.5

García-Luna, M.A., Cortell-Tormo, J.M., González-Martínez, J., & García-Jaén, M. (2020). The effects of tissue flossing on perceived knee pain and jump performance: A pilot study. *International Journal of Human Movement and Sports Sciences, 8*, 63-68. https://doi.org/10.13189/saj.2020.080203

Gates, D. H., Walters, L. S., Cowley, J., Wilken, J. M., & Resnik, L. (2016). Range of Motion Requirements for Upper-Limb Activities of Daily Living. *The American Journal of Occupational Therapy*, *70*(1), 7001350010p1-7001350010p10. https://doi.org/10.5014/ajot.2016.015487

Guillén-Rogel, P., San Emeterio, C., & Marín, P. J. (2017). Associations between ankle dorsiflexion range of motion and foot and ankle strength in young adults. *The Journal of Physical Therapy Science*, *29*(8), 1363–1367. https://doi.org/10.1589/jpts.29.1363

Halabchi, F., & Hassabi, M. (2020). Acute ankle sprain in athletes: Clinical aspects and algorithmic approach. *World Journal of Orthopedics*, *11*(12), 534–558. https://doi.org/10.5312/wjo.v11.i12.534

Halperin, I., Aboodard, S. J., Button, D. C., Andersen, L. L., & Behm, D. G. (2014). Roller massager improves range of motion of plantar flexor muscles without subsequent decreases in force parameters. *International Journal of Sports Physical Therapy*, *9*(1), 92–102.

Hernández-Guillén, D., Tolsada-Velasco, C., Roig-Casasús, S., Costa-Moreno, E., Borja-de-Fuentes, I., & Blasco, J.M. (2021). Association ankle function and balance in community-dwelling older adults. *PLoS One*, *16*(3), e0247885. https://doi.org/10.1371/journal.pone.0247885

Hewett, T. E., & Bates, N. A. (2017). Preventive Biomechanics: A Paradigm Shift With a Translational Approach to Injury Prevention. *The American Journal of*

Sports Medicine, *45*(11) 2654–2664. https://doi.org/10.1177/0363546516686080

Hoch, M. C., Farwell, K. E., Gaven, S. L., & Weinhandl, J. T. (2015).Weight-Bearing Dorsiflexion Range of Motion and Landing Biomechanics in Individuals With Chronic Ankle Instability. *Journal of Athletic Training*, *50*(8), 833–839. https://doi.org/10.4085/1062-6050-50.5.07

Hyodo, K., Masuda, T., Aizawa, J., Jinno, T., & Morita, S. (2017). Hip, knee, and ankle kinematics during activities of daily living: a cross-sectional study. *Brazilian Journal of Physical Therapy*, *21*(3), 159–166. https://doi.org/10.1016/j.bjpt.2017.03.012

Jung, H., Tanaka, S., Iwamoto, Y., Kawano, T., Yamasaki, M., & Tanaka, R. (2021). Reductions in Muscle Strength and Range of Motion Cause Locomotion Disability via Locomotion-Related Functional Limitation in Japanese Older Adults: A Cross-Sectional Study. *Journal of Aging Research*, 6627767. https://doi.org/10.1155/2021/6627767

Kaneda, H., Takahira, N., Tsuda, K., Tozaki, K., Kudo, S., Takahashi, Y., Sasaki, S., & Kenmoku, T. (2020). Effects of Tissue Flossing and Dynamic Stretching on Hamstring Muscles Function. *Journal of Sports Science and Medicine*, 19(4), 681–689.

Katz, D. L., & Ali, A. (2009). *Preventive medicine, integrative medicine & the health of the public*. Summit on Integrative Medicine and the Health of the Public.

Kelly, S., & Beardsley, C. (2016). Specific and cross-over effects of foam rolling on ankle dorsiflexion range of motion. *International Journal of Sports Physical Therapy*, *11*(4), 544–551.

Kiefer, B., Lemarr, K., Enriquez, C., & Tivener, K. (2017). A pilot study: Psychological effects of the voodoo floss band on glenohumeral flexibility. *International Journal of Athletic Therapy and Training*, *22*, 1-16. https://doi.org/10.1123/ijatt.2016-0093

Kim, S. G., & Kim, W.S. (2018). Effect of Ankle Range of Motion (ROM) and Lower-Extremity Muscle Strength on Static Balance Control Ability in Young Adults: A Regression Analysis. *Medical Science Monitor*, *24*, 3168-3175. https://doi.org/10.12659/MSM.908260

Kolokotsios, S., Drousia, G., Koukoulithras, I., & Plexousakis, M. (2021). Ankle Injuries in Soccer Players: A Narrative Review. *Cureus*, 13(8), e17228. https://doi.org/10.7759/cureus.17228

Konrad, A., Močnik, R., & Nakamura, M. (2021). Effects of Tissue Flossing on the Healthy and Impaired Musculoskeletal System: A Scoping Review. *Frontiers in Physiology*, *12*, 666129. https://doi.org/10.3389/fphys.2021.666129

Leavell, H. R., & Clark, E.G. (1965). *Preventive medicine for the doctor in his community* (3rd ed). McGraw-Hill Book Company.

Manoel, L. S., Xixirry, M. G., Soeira, T. P., Saad, M. C., & Riberto, M. (2020). Identification of Ankle Injury Risk Factors in Professional Soccer Players Through a Preseason Functional Assessment. *Orthopaedic Journal of Sports Medicine*, *8*(6), 2325967120928434. https://doi.org/10.1177/2325967120928434

Maust, Z., Bradney, D., Collins, S.M., Wesley, C., & Bowman, T. G. (2021). The Effects of Soft Tissue Flossing on Hamstring Range of Motion and Lower Extremity Power. *International Journal of Sports Physical Therapy*, *16*(3), 689–694. https://doi.org/10.26603/001c.24144

Mills, B., Mayo, B., Tavares, F., & Driller, M. (2020). The Effect of Tissue Flossing on Ankle Range of Motion, Jump, and Sprint Performance in Elite Rugby Union Athletes. *Journal of Sport Rehabilitation, 29*(3), 282–286. https://doi.org/10.1123/jsr.2018-0302

Ness, B. M., Sudhagoni, R. G., Tao, H., Full, O. R., Seehafer, L. O., Walder, C. M., & Zimney, K. (2018). The reliability of a novel heel-rise test versus goniometry to assess plantarflexion range of motion. *The International Journal of Sports Physical Therapy*, *13*(1), 19–27.

Pakarklis, D., & Siupsinskas, L. (2018). Instant Effects On Tissue Flossing On Ankle Range Of Motion And Dynamic Balance. In *Handball Players, Book of Abstracts of the 4th International Scientific-Practical Conference Exercise for health and rehabilitation* (pp. 33–34). https://hdl.handle.net/20.500.12512/98152

Rahnama, N. (2011). Prevention of football injuries. *International Journal of Preventive Medicine*, *2*(1), 38–40.

Starrett, K., & Cordoza, G. (2013). *Becoming a Supple Leopard: The Ultimate Guide to Resolving Pain, Preventing Injury, and Optimizing Athletic Performance*. Victory Belt Publishing Inc.

Stevenson, P. J., Stevenson, R. K., & Duarte, K.W. (2016). Acute Effects of The Voodoo Flossing Band on Ankle Range of Motion. *Journal of Medical Biomedical and Applied Sciences, 7*(6), 244-253. https://doi.org/10.15520/jmbas.v7i6.190

Suga, T., Terada, M., Tomoo, K., Miyake, Y., Tanaka, T., Ueno, H., Nagano, A., & Isaka, T. (2021). Association between plantar flexor muscle volume and dorsiflexion flexibility in healthy young males: ultrasonography and magnetic resonance imaging studies. *BMC Sports Science, Medicine and Rehabilitation*, *13*(1), 8. https://doi.org/10.1186/s13102-021-00233-z

Vogrin, M., Novak, F., Licen, T., Greiner, N., Mikl, S., & Kalc, M. (2020). Acute Effects of Tissue Flossing on Ankle Range of Motion and Tensiomyography Parameters. *Journal of Sport Rehabilitation*, *30*(1), 129–135. https://doi.org/10.1123/jsr.2019-0160

Walls, R. J., Ross, K. A., Fraser, E. J., Hodgkins, C. W., Smyth, N. A., Egan, C. J., Calder, J., & Kennedy, J. G. (2016). Football injuries of the ankle: A review

of injury mechanisms, diagnosis and management. *World Journal of Orthopedics*, 7(1), 8–19. Published 2016 January 18. https://doi.org/10.5312/wjo.v7.i1.8

Woods, C., Hawkins, R., Hulse, M., & Hodson, A. (2003). The Football Association Medical Research Programme: an audit of injuries in professional football: an analysis of ankle sprains. *British Journal of Sports Medicine*, *37*(3), 233–238. https://doi.org/10.1136/bjsm.37.3.233

Wu, S. Y., Tsai, Y. H., Wang, Y.T., Chang, W-D., Lee, C-L., Kuo, C-E. A., & Chang, N-J. (2022). Acute Effects of Tissue Flossing Coupled with Functional Movements on Knee Range of Motion, Static Balance, in Single-Leg Hop Distance, and Landing Stabilization Performance in Female College Students. *International Journal of Environmental Research and Public Health*, *19*(3), 1427. https://doi.org/10.3390/ijerph19031427

Young, R., Nix, S., Wholohan, A., Bradhurst, R., & Reed, L. (2013). Interventions for increasing ankle joint dorsiflexion: a systematic review and meta-analysis. *Journal of Foot and Ankle Research*, *6*(1), 46. Published 2013 November 14. https://doi.org/10.1186/1757-1146-6-46