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ASPECTS OF THE IMPORTANCE OF FIRST METATARSOPHALANGEAL JOINT IN THE PROCESS OF GAIT RECOVERY

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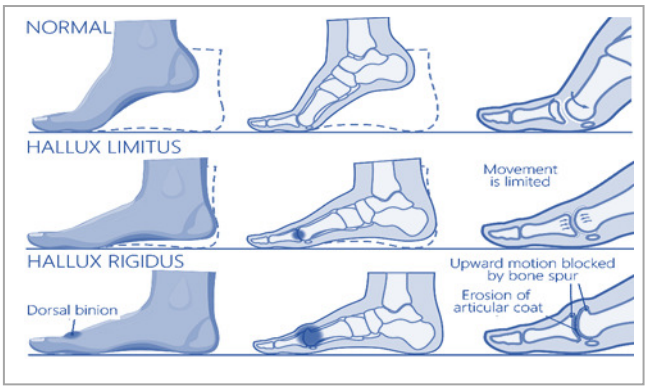
Abstract

The purpose of the present scientific research is to take into consideration the importance of rehabilitation of the first metatarsophalangeal joint in the process of physio cycling in order to recover the gait. Hypothesis: patients over 55 age has hallux rigidus that determine the vicious angulation of the ankle by reduction of the normal range of motion. The aim of this research is to analyses the possibility of applying kinetic programs for the first metatarsophalangeal joint too, in the process of horizontal cycling. Recovering the independence of gait in order to improve the quality of life it is a crucial factor of rehabilitation. Materials and Methods: 19 patients over 55 years age, period November 2020- March 2021 diagnosed with different pathologies (excluding amputation) that affects lower limbs and with indication for physiotherapy and Visual Analog Scale maxim 4. Determination of active dorsiflexion and active plantarflexion of the first metatarsophalangeal joint was proceed according to American Medical Association scale of grading. Pearson correlation between right and left foot of the first metatarsophalangeal joint are strong.The most common grade is 3 both for left and right foot on dorsiflexion and plantarflexion, approximately equal distribution on gender. Kinetic program can be used only for the first 3 grades according AMA and hallux rigidus severity grades 0-2. In the process of gait recovery may be possible physiotherapy for 12 patients for the 1st MTF joint among the other programs for kinetic chain.

Keywords*: hallux limitus-rigidus, metatarsophalangeal joint, range of motion, activ goniometry*



1. Introduction;

The difference between performance and recovery using physio cycling is to use the movement of total ROM of MTP and ankle. Performance cycling blocks ROM of MTP joint in order to use total force of quadriceps and Gluteus maximus, Semimembranous. Muscles involved in cycling are as in figure 1. For the measurement of the 1 st MTP joint motion was based on goniometry according to American Medical Association (AMA) standards:

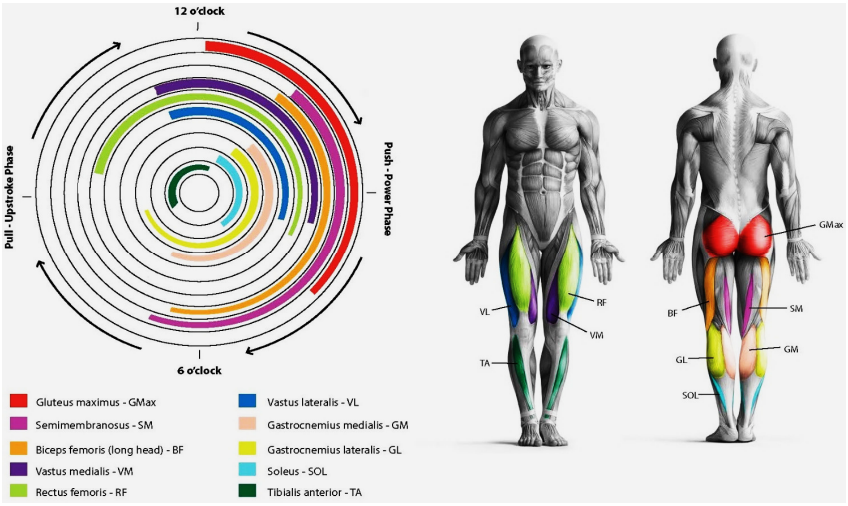


Figure 1 Stress-Strain relation – Muscles involved in cycling after "The Secret of Cycling"(13)

In this respect it was considered the possibility of improvement of the 1st MTF joint to recover an correct gait using a physio-bike**.** First metatarsophalangeal joint integrity influences the kinetic chain of the lower limbs so it is crucial to have o good function of it by improving structure components and revers. Wolff's Law states that bones will adapt to the degree of mechanical loading, based on the stress or demands placed on them or stress-strain relation. (10). The process bases on the core principle that function determines the structure and an appropriate structure maintains the function.

Examination before articular testing of the subjects of the 1st metatarsal-phalangeal joint involved: inspection-looking for Celsus signs: rubor- redness, calor -heat, tumor - tumefaction, dolor - pain and functional impotence, callus pattern or obvious deformity;palpation of the joint for areas that cause pain, percution and auscultation – crackments; measurements - the range of motion of the joint was tested according AMA standards.

If the MTP joint has a reduced ROM during the test, it is a tell-tale sign of a condition called functional hallux limitus or hallux rigidus classification. (11) The movement is limited during gait due to the blockage of this function - commonly known as "jamming up". (2) in phaces 3

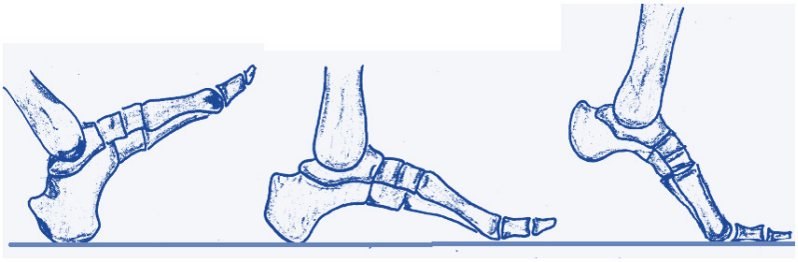


Figure 2. Three phases of gait: contact, midstance, propulsion after (6)

One of the most important targets of physiotherapy is the recover the gait, the independence of Activities of Daily Living (ADL) and well-being state.

American Medical Association provide values for MTP joint of the first toe. In general, flexion and extension of the first toe is greater than flexion and extension of the lesser toes.It was considered the MTP joint to be at 0 degrees when the metacarpal and proximal phalanx are in a straight line. (1,4). Measurements of the MTP joint varied as to whether the goniometer was aligned on the dorsal or medial aspect. (4,5)

Hallux limitus refers to the stiffness of big toe joint - a condition that is characterized by a decreased range of motion and pain at first metatarsophalangeal joint. Hallux Rigidus (or Hallux Limitus) is a degenerative condition leading to reduced rang of motion in the first metatarsophalangeal (MTP) joint of the big toe or great toe which can impair normal gait function, during the propulsive phase. Physiotherapeutic exercise for joint amplitude- the maximum possible length can be used, not the force (8)

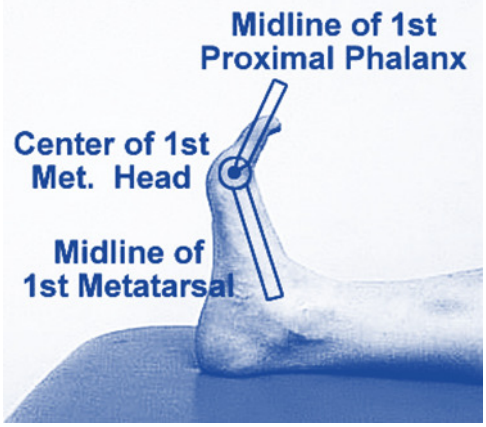
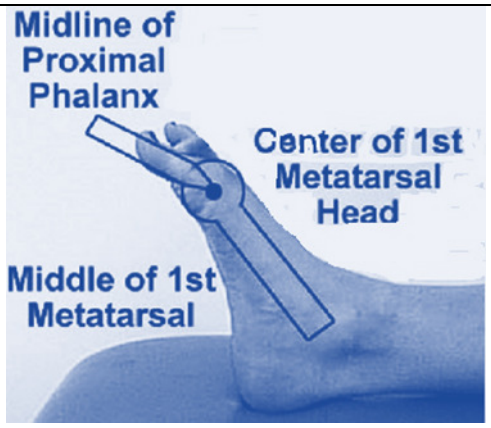
2. Materials and methods

Subject: 19 patients over 55 years age from own portfolio from period November 2020- March 2021 diagnosed with different pathologies (excluding amputation) that affects lower limbs and with indication for physiotherapy. Determination of active dorsiflexion and active plantarflexion of the first metatarsophalangeal joint was proceed according to American Medical Association scale of grading.

Procedures: Goniometry - Axis – medial to center of metararsal head; Stationary arm – aligned metatarsal, Moving arm – aligned with proximal phalange.

In the present study, I considered medial goniometry and subject in supine position.

Tabel 1 Goniometry normal values after (12)

Metatarsophalangeal Joint Dorsiflexion	**Metatarsophalangeal Joint Plantarflexion**
 Source (9) Goniometry, Dr. Benjamin Saviet	 Source (9) Goniometry, Dr. Benjamin Saviet
Normal degrees (9) 65° to 75°	**Normal degrees (9) >30°**

All subjects evaluated in according to AMA standards and interpretation of the results considered as in table 2.

Tabel 2 AMA standards versus grading hallux rigidus severity

1 stMTP Grade	**Plantar Flexion (AMA)o**	**Dorsal Flexion (AMA)o**	**Grading hallux rigidus severity (3)**	**Clinical findings (3)**	**Treatment (except medication)**
1	50	30	**0**	No pain; only stiffness and loss of motion on examination	phisiotherapy
2	40	30	**1**	Mild or occasional pain and stiffness; pain at extremes of dorsiflexion and/or plantarflexion on examination	phisiotherapy

3	30	20	**2**	Moderate-to-severe pain and stiffness constant; pain occurs just before maximum dorsiflexion and maximum plantar flexion on examination	phisiotherapy
4	20	10	**3**	constant pain; substantial stiffness at extremes of ROM but not at midrange	surgery
5	10	10	**4**	3 +definite pain at midrange of passive motion	surgery

Microsoft Excel used for general data and IBM SPSS Statistics software, Version 25 was used to calculate correlations, means, and deviations from standards, frequency, and domination.

3. Results

Demographic variables: Age: four groups of patients: 55-60 years, 61-65 years, 66-70 years – 26.32%, over 70 years – 21.05% . Fisher test $\chi^2 > 7.81$, $\varphi > 0.4$, ratio Cohen >0.4 shows strong relation between 1st MFP joint redused ROM and all groups of age.

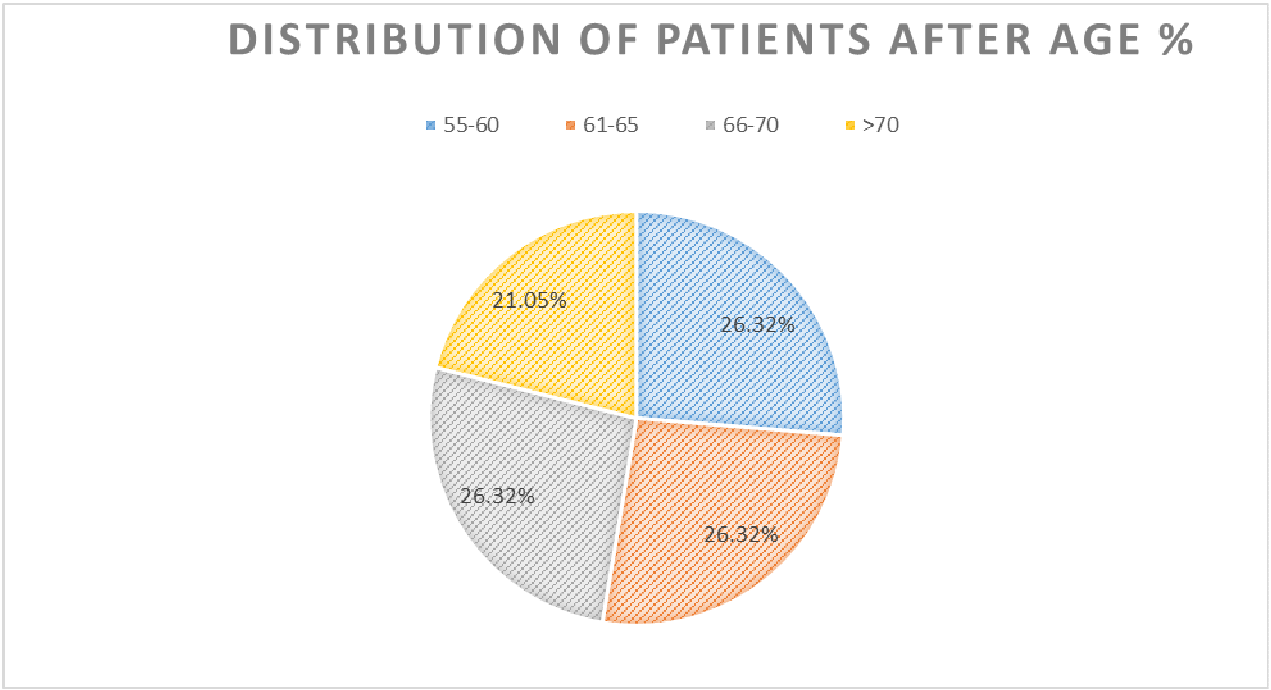


Figure 3 Distribution of patients after age (%)

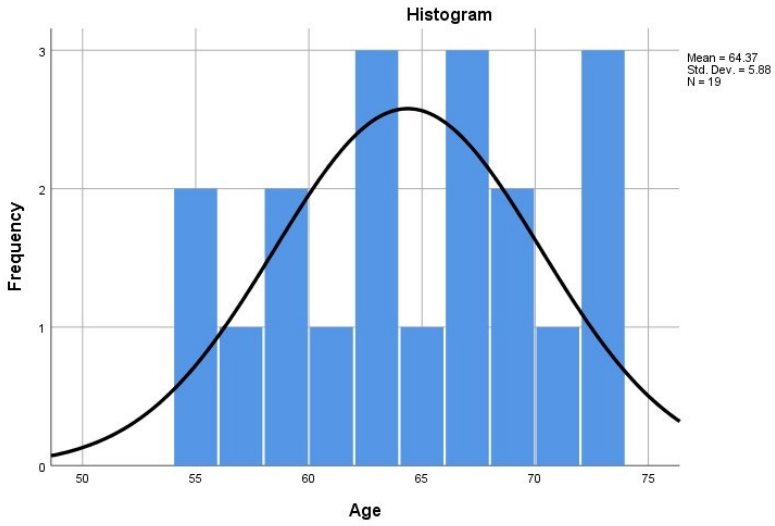
Mean age = 64.37 ± 5.880; Std. Deviation; Min= 55, Max = 73; notable difference between 55-60 years and >70 years.

Tabel 3 Mean/Std. Deviation Age/Frequency

Statistics

Age

N	Valid	19
	Missing	0
Mean		64.37
Std. Deviation		5.880
Minimum		55
Maximum		73
Percentiles	25	59.00
	50	64.00
	75	69.00



Gender: From 19 patients there are 9 women and 10 men. Men are 60% in age groups: 66-70 years and 55-60 years, statistical significant (α>0.05).

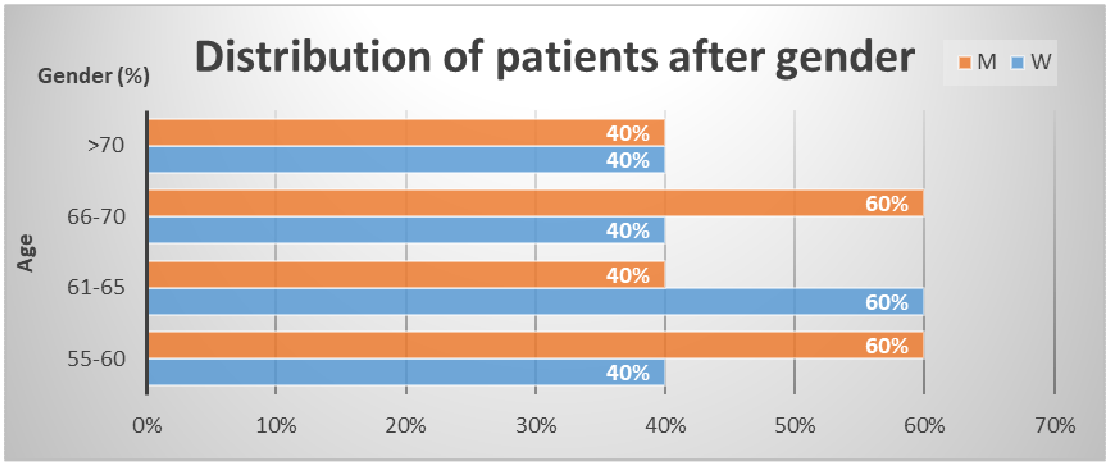


Figure 4 Distribution of patients after gender (%)

Clinical variables.

VAS: all patients have a VAS of pain < 4 points, with an average of 3.75 for patients over 70 years. (significant correlation with age Fisher test χ^2 > 7.81, ω > 0.4, ratio Cohen >0.4 strong relation between 1st MFP joint redused ROM and gender, α >0.05)

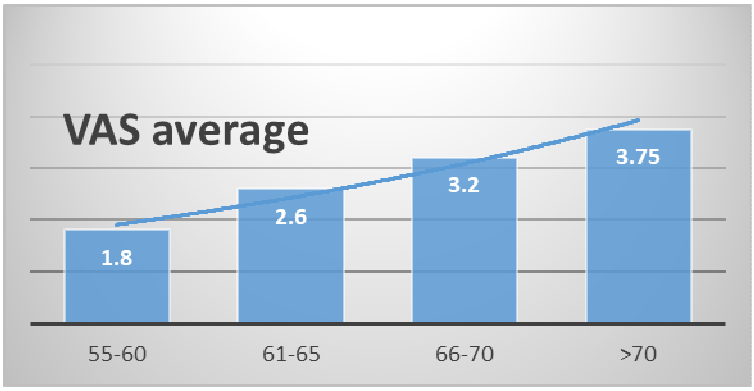


Figure 5 Distribution of patients after VAS average

Goniometry of 1st MTP joint for right and left foot according AMA

Tabel 4 Goniometry of 1st MTP joint for right and left foot according AMA

Age	Total	W	M	W	M	55-60	W	M	61-65	W	M	66-70	W	M	>70
Count	19	9	10	2	2	5	3	2	5	2	3	5	2	2	4
DF 1MTP R1	1	1	0	1		1									
DF 1MTP R2	7	3	4	1	2	3	1	1	2		1	1	1		1
DF 1MTP R3	9	4	5		1	1	2	1	3	2	2	4		1	1
DF 1MTP R4	2	1	1										1	1	2
DF 1MTP L1	0	0	0												
DF 1MTP L2	5	1	4	1	2	3					1	1		1	1
DF 1MTP L3	8	3	5	1	1	2	1	2	3		1	1	1	1	2
DF 1MTP L4	5	4	1				2		2	2	1	3			

DF 1MTP L5	1	1	0										1		1
PF 1MTP R1	3	1	2	1	1	2		1	1						
PF 1MTP R2	4	3	1	1		1	1		1		1	1	1		1
PF 1MTP R3	11	4	7		2	2	2	1	3	2	2	4		2	2
PF 1MTP R4	1	1	0										1		1
PF 1MTP L1	0	0	0												
PF 1MTP L2	4	1	3	1	1	2		1	1					1	1
PF 1MTP L3	14	7	7	1	2	3	3	1	4	2	3	5	1	1	2
PF 1MTP L4	1	1	0										1		1

DF – dorsal flexion, PL – plantar flexion, R – right, L - left

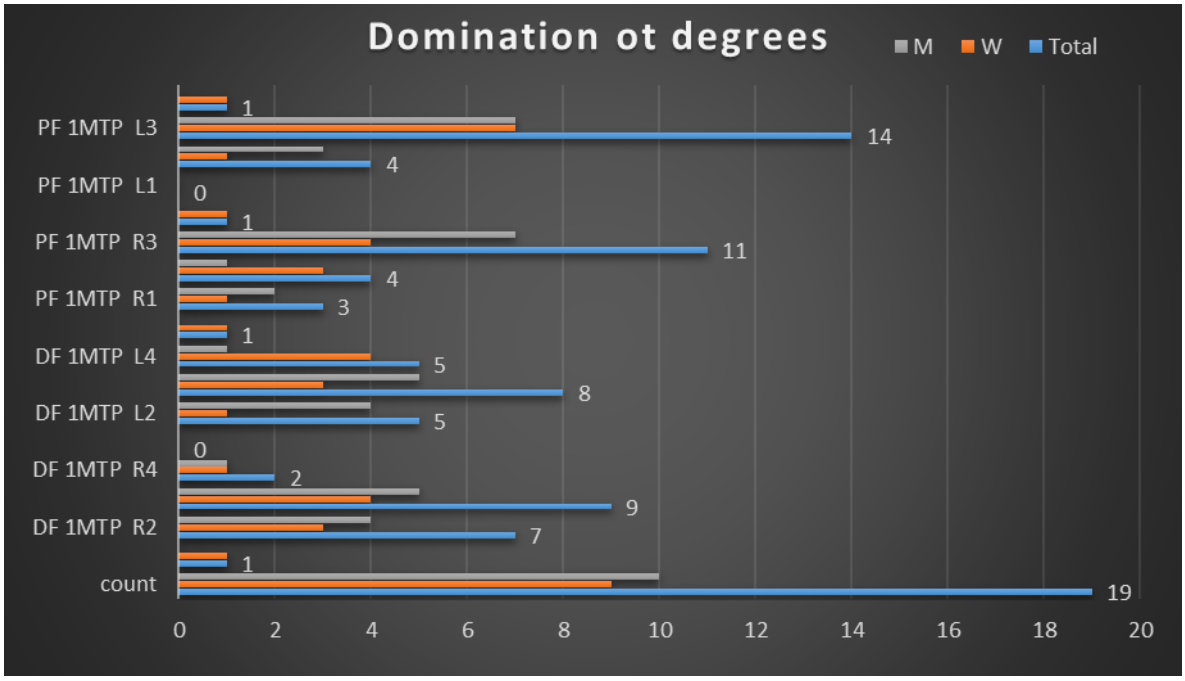


Figure 6 Domination of degrees

From 19 patients: 14 items have **grade 3 for left foot – plantar flexion**, 11 items **grade 3 for right foot – plantar flexion** followed by 9 items grade 3 for dorsal flexion, 8 items grade 3 for dorsal flexion and 7 items grade 2 dorsal flexion with statistical significance (α>0.05, Fisher test χ^2)

Tabel 5 Mean. Sd. Deviation according AMA

Descriptive Statistics

	Mean	Std. Deviation	N
DF 1MTP R1	1.00	.	1
DF 1MTP R2	1.75	.957	4
DF 1MTP R3	2.25	1.500	4
DF 1MTP R4	2.00	.	1
DF 1MTP L1	.	.	0
DF 1MTP L2	1.67	1.155	3
DF 1MTP L3	2.00	.816	4
DF 1MTP L4	2.50	.707	2
DF 1MTP L5	1.00	.	1
PF 1MTP R1	1.50	.707	2
PF 1MTP R2	1.00	.000	4
PF 1MTP R3	2.75	.957	4
PF 1MTP R4	1.00	.	1
PF 1MTP L1	.	.	0
PF 1MTP L2	1.33	.577	3
PF 1MTP L3	3.50	1.291	4
PF 1MTP L4	1.00	.	1

It is noticed that the highest values are: 3.50 for **PF L3**, 2.75 for **DF R3**.

Pearson correlation between right and left foot are strong between: **DF R3-PF L3**, r = 0.947 [CI = 95%]

This means that a patients who has affected the 1st MTP joint of the left foot PF – grade 3 will have probably the right foot affected on DF – grade 3, that is important to gait recovery.

Regarding the distribution on genders the mean has no differences W/M but the standard deviation on men is variated reported to age groups. Pearson Correlation r = 0.705 means a strong corellation for both men and women, age over 55 years and redused ROM of the 1st MTP joint.

Tabel 6 Mean/ Std. Deviation after gender of 1st MTF/Pearson Corellation

Descriptive Statistics			
	Mean	Std. Deviation	N
W	2.40	1.805	15
M	2.67	2.526	15

Correlations

		W	M
W	Pearson Correlation	1	.705**
	Sig. (2-tailed)		.003
	N	15	15
M	Pearson Correlation	.705**	1
	Sig. (2-tailed)	.003	
	N	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

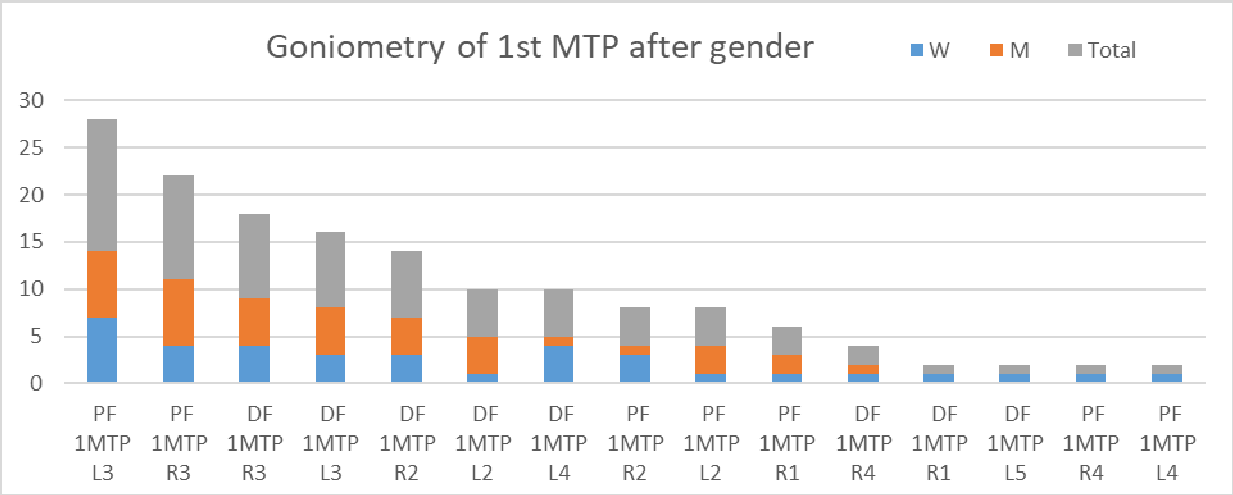


Figure 7 Goniometry of 1st MTF after gender

The most common grade is 3 both for left and right foot on DF and PF, approximately equal distribution on gender.

4. Discussion

Findings according different studies: MTP extension ROM of the first toe was greater when measured medially than dorsally, decreasing with age for MTP extension (dorsiflexion) and less of a difference for flexion (plantarflexion), women have greater ROM in plantarflexion than men and males have greater active and passive dorsiflexion ROM than females.(7)The decrease in extensibility of the plantarflexor muscle–tendon unit was due to connective tissue changes associated with the aging process.Both males and females showed a consistent trend toward decreasing ROM with increasing age, but females had a larger decrease than males.(14,15)

5. Perspective

Tabel 7 Perspectives of gait recovery

Goniometry	Total	Hallux rigidus grades	Perspectives
PF 1MTP L3	14	2	Phsioterapy
PF 1MTP R3	11	2	Phsioterapy
DF 1MTP R3	9	2	Phsioterapy
DF 1MTP L3	8	2	Phsioterapy
DF 1MTP R2	7	1	Phsioterapy
DF 1MTP L2	5	1	Phsioterapy
DF 1MTP L4	5	3	Phsioterapy after Surgery
PF 1MTP R2	4	1	Phsioterapy
PF 1MTP L2	4	1	Phsioterapy
PF 1MTP R1	3	0	Phsioterapy
DF 1MTP R4	2	3	Phsioterapy

DF 1MTP R1	1	0	Phsioterapy
DF 1MTP L5	1	4	Phsioterapy after Surgery
PF 1MTP R4	1	3	Phsioterapy after Surgery
PF 1MTP L4	1	3	Phsioterapy after Surgery

6. Conclusions

1. The groups of age under comparison were homogeneous as number. Fisher test $\chi^2 >$ 7.81, $\omega > 0.4$, ratio Cohen >0.4 shows strong relation between 1st MFP joint redused ROM and all groups of age.

2. Mean age = 64.37 ± 5.880; Std. Deviation; Min= 55, Max = 73; notable difference between 55-60 years and >70 years.

3. From 19 patients there are 9 women and 10 men. Men are 60% in age groups: 66-70 years and 55-60 years, statistical significant ($\alpha > 0.05$).

4. **A**ll patients have a VAS of pain < 4 points, with an average of 3.75 for patients over 70 years.

Significant correlation with age: Fisher test $\chi^2 > 7.81$, $\omega > 0.4$, ratio Cohen >0.4 strong relation between 1st MFP joint redused ROM and gender, $\alpha > 0.05$.

5. From 19 patients: 14 items have **grade 3 for left foot – plantar flexion**, 11 items **grade 3 for right foot – plantar flexion** followed by 9 items grade 3 for dorsal flexion, 8 items grade 3 for dorsal flexion and 7 items grade 2 dorsal flexion (AMA standards) with statistical significance at Fisher test χ^2 ($\alpha > 0.05$).

6. Pearson correlation between right and left foot are strong between **DF R3-PF L3** = 0.947, AMA standards.[CI = 95%].

7. Pearson Correlation r = 0.705 means a strong corellation for both men and women, age over 55 years and redused ROM of the 1st MTP joint

8. The most common grade is 3 both for left and right foot on DF and PF, approximately equal distribution on gender.

9. Kinetic program can be used only for the first 3 grades according AMA and **hallux rigidus severity grades 0-2**.

10. In the process of gait recovery may be possible physiotherapy for 12 patients for the 1st MTF joint among the other programs for kinetic chain.

7. References

1. American Medical Association: Guides to the Evaluation of Permanent Impairment, ed 3 (revised). AMA, Chicago, 1988.

2. Central Massachusetts Podiatry, Book on line Functional hallux limitus: big-toe movement affects the rest of your foot and body accessed on 21.03.2021 (https://www.centralmasspodiatry.com/blog/functional-hallux-limitus-your-big-toe movement-affects-the-rest-of-your-foot-and-body)

3.Coughlin MJ, Shurnas PS. J Bone Joint Surg Am 85-A(11):2072–2088, 2003

4.Cynthia C. Norkin, PT, D. Joyce White, Measurement of joint motion a guide to goniometry, pp 387-402, EdD Fifth Edition, 2016

5. Hopson, M, McPoil, TG, and Cornwall, MW: Motion of the first metatarsophalangeal joint: Reliability and validity of four measurement techniques. J Am Podiatr Med Assoc 85(4):199, 1995.

6. Jeffrey D. Olsen, DC, The Biomechanics of Gait, Education Resources Center, 2021 accessed on 26.03.2021 (http://www.footlevelerseducation.com/the-biomechanics-of-gait/)

7. Nigg, BM, et al: Range of motion of the foot as a function of age. Foot Ankle 613:336, 1992.

8. Physiopedia, Online courses, Hallux Rigidus, accessed on 21.03.2021 (https://www.physio-pedia.com/Hallux_Rigidus)

9. Root, Orien, Weed. Normal and Abnormal Function of the Foot, pp. 60-61, Clinical Biomechanics Corp., Los Angeles, 1977

10.Sbenghe T, Kinesiology - The science of movement, pp 36,Medical Publishing House, 2008,

11. Schwab J., Khazzam M, Foot and ankle motion - Hallux Rigidus: A Pre- and Postoperative Analysis of Gait, pp. 234, Biomechanical Engineering Series, 2008

12.University of Scanton, Goniometry, Dr. Benjamin Saviet, accessed on 19.03.2021 (https://www.scranton.edu/faculty/kosmahl/courses/gonio/lower/pages/meta-dors.shtml)

13. Van Dijk H, Van Megen R, Vroemen G, The secret of cycling,pp. 215, Meyer & Meyer Sport 2017

14. Walker, JM, et al: Active mobility of the extremities of older subjects.Phys Ther 64:919, 1984

15. Vandervoort, AA, et al: Age and sex effects on the mobility of the human ankle. Gerontol 476:M17, 1992