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COMPARATIVE ANALYSIS OF WALKING TYPOLOGIES IN RELATION TO LOWER LIMB JOINTS LOCK

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Abstract: *In this paper we present some theoretical considerations and experimental biomechanical analysis of gait typologies in subjects with foot joints blocked. The theoretical aspects of the gait cycle, parameters and limits defining the gait cycle but also an analysis of gait typologies developed by a healthy subject walking are presented in the first part of the paper. The principles and methodology for investigating structure of gait typologies vs. locking joints legs and experimental aspects highlighted during the developed analysis are also presented in the second part. In the third part of the paper are presented the results of this comparative analysis and correlation strategies and also are defined some data by determining the dynamic correlation coefficient. In the final part of the paper, conclusions of the investigations are set by records analyses. Also are presented the development of biomechanical investigations for comparative evaluations and future directions of the studies.*
Keywords: *gait, biomechanics, joint, correlation*

1. INTRODUCTION

Gait cycle is characterized by a series of static and dynamic parameters that can be measured during performance of. Human subject moving into the space and permanent interaction with the environment is due musculoskeletal and its components: bones, muscles and joints.
The totality of bones forms the human skeleton, helping to the shape and body posture. Bones are connected by joints making it possible human mobility and movements.
The passive part of the locomotor system is made up by bones and joints; and active part in all muscles, due to which movement is possible.
Musculoskeletal components represent a large part of the total mass of the human body respectively 52% of the total weight of an adult. From this percentage, 38% represents musculature and 14% represents skeleton. These values are variable depending on the individual's age and physical training of him. [1]
Activity of locomotion (bones, joints and muscles) is not independent but is closely related to other components of the human body (Fig.1).

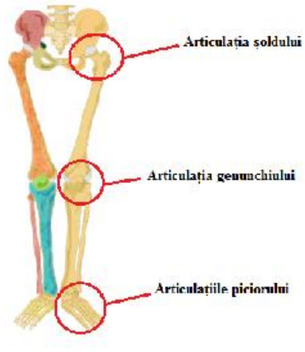

Figure 1: The human leg joints

Particularly important is the connection between the musculoskeletal system and nervous system. In the absence of this nervous system, the locomotor system would "be an inert mass or group that would operate heterogeneous and anarchic". [1]

About half of the human skeleton jointings are joints, skeletal joints very mobile.
If the lower limb joints belt they fall into the lower limb joints (pelvic belt) and lower limb joints free. Among the lower limb joints can freely include hip joint (hip), knee joints and leg joints tibio-femural.
Of all the joints of the lower limb kinematics shows great complexity hip joint, knee and foot joints. Hip joint is formed by joining, using ligaments, between the femoral head and acetabulum of the hip.
The movements they perform hip joint, from Fig. 2 are: flexion / extension (near that removing thigh abdomen), adduction / abduction (carrying thigh towards the body that sideways), external rotation (twisting thigh outwards) and circumduction (movement that combined movements listed). [2]

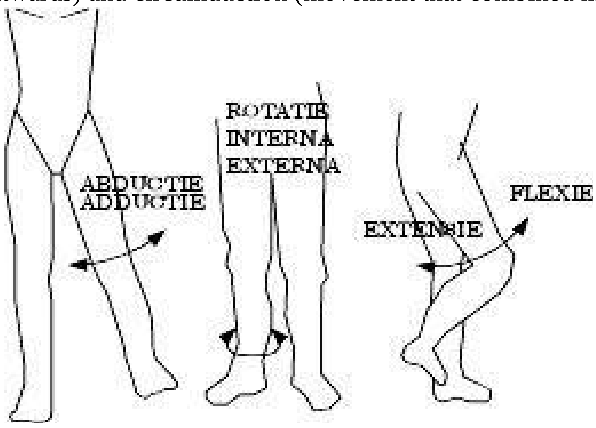

Figure 2: The movements of the hip joint [4]

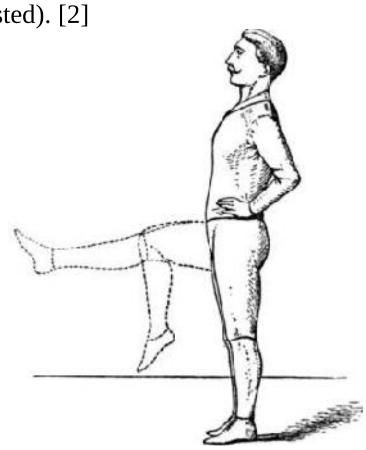

Figure 3: Knee joint movements [5]

Knee joint, considered the most voluminous and powerful body joint, unites a series of thigh leg ligaments. If a human subject, in standing position when support is distributed evenly over both legs, whole body weight is transmitted through the end of the femoral knee and hence the girls planting the direction of the femoral head, knee and ankle. [3]
The knee joint has one degree of freedom and allows two main movements: flexion and extension leg on the thigh (Figure 3). In flexion the posterior calf approaches the back of the thigh; and if extension occurs remoteness rear face of the leg of the back of the thigh.
In flexion / extension leg acts as an open kinematic chain and knee levers acting on the principle of third degree. Limiting movement of flexion is achieved by meeting face with the back hind leg and thigh extension movement is limited by ligaments. [3]
The link between the foot and lower leg ankle joint is made of. It consists of pillar tibial malleolus lateral talus and connected by ligaments. Leg joints are talocrurala articulation (neck leg) joints intertarsiene joints tarso-metatarsal joints, joints and finger joints inter-metatarsiene.
They perform leg movements are flexion / extension (talocrurale joint movements) and your truly / pronation (inter-tarsienes joints movements). [2] Movement is the movement of your truly the plant foot "concerns" are oriented toward the midline and the movement of pronation is when the plant "looks" are oriented to the side. [6]
Human walking is considered to be a cyclical movement performed by positioning a successful leg before the other. The main mechanism that relies walking is considered "alternative and constant movement of the two legs, which in turn assumes the function of support and function of propellant" [7].
This mechanism has been defined in the specialized work as an "alternative bipedalism" (Steindler) or as' a fall continues to lift its own "(Holmes). [7]
Human walking is cyclical drive unit (double step), namely the distance between the point of contact with the ground (heel) of a leg and immediately following point of contact of the same foot. [8] Loco-motor movements are learned in childhood and are settled in the central nervous system so that the driving elements are the same for all people.
The setting of the walking reflex, an important role is sensitive receptors in the muscles, tendons, ligaments and joints.
Walking is influenced by age, sex and individual body constitution, so this is personal to each individual. [6] Human walking is composed of a step in the cycle leg becomes successively as rod and pendulum while driving element (Figure 4).
Each gait cycle consists of a phase support bilateral and unilateral support phase and can be described as [6] [7]:
1. Bending the trunk forward (center of gravity will be screened before the supporting body), while the leg is thrown forward;
2. Extension of one of the legs simultaneously pendulum and the other member becomes detached from the ground up to be designed before;
3. A member pendulum will be screened again on the ground before the member support;
4. This cycle is repeated, reversing limbs and functions;

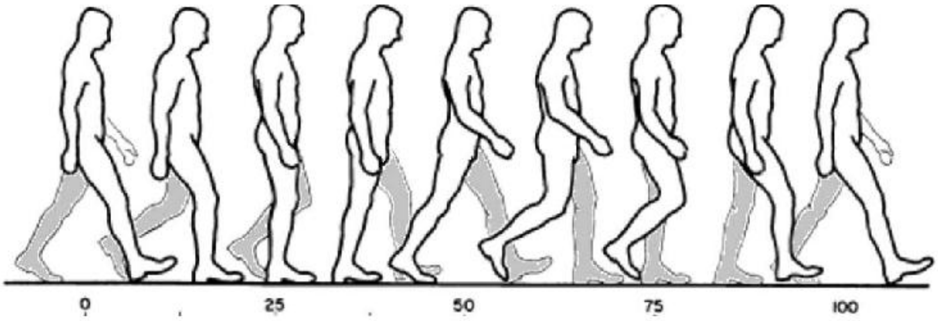

Figure 4: Gait cycle

Gait cycle is defined as a series of steps and comprises a double step that corresponds to the time between two taps on the ground by the same calculation. [6] Step defined in the literature by various authors as "the interval between two supports" or "double-step, corresponding to the series of movements which succeed one another between two positions identical to one foot". [7]

2. EXPERIMENTAL SETUP

This study aims to analyze the patient's behavior where it has ankle or knee mobilized (compared to walking in normal conditions) in order to help the patient after a pathology shows the problem or dysfunction of the gait cycle or stability Stations.

Pilot plant used in this experiment consists of RSScan pressure plate type, data acquisition and processing software " Footscan 7 Gait 2nd Generation" anthropometry and equipment (goniometer, rulers, anthropometry). (fig.5.)

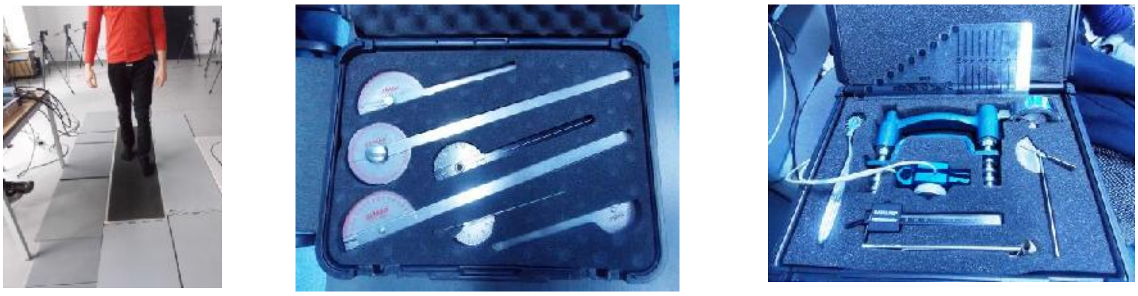

Figure 5: Equipments for experimental setup (RSScan plate, goniometer, anthropometric kit)

Measurements were recorded on RSScan board, the length of 2 m, and associated software " Footscan 7 Gait 2nd Generation. The experiment was conducted dynamically moving patient on the pressure plate in a given time. There are three measurements made on each gait cycle in order to obtain reliable and comparable data sets.

Types walk examined: normal walking, cycling step added, running knee to the chest, walking march, reversing and going sideways. They were chosen because these types of walking are considered to be most common in daily activity. For each of these types of gait measurements were performed three consecutive walk the cycle began with the left foot and right foot 3 measurements. Subjects in this experiment participants had, in turn, right ankle and then locked in these conditions were recordings of drive types listed above.

Figure 6: Gait cycles type – march, with knee up, back gait, lateral, added step

The pressure plate type RSScan recorded via the sensors 16384/2 m pressure (force) created by the soles area in contact with the ground. These values are then compared between subjects (male, female) and different forms of the gait cycle

3. RESULTS AND CONCLUSIONS

Analyses conducted on subjects aimed primarily determine normal variant walk without constraints in the joints of the foot and then established a procedure for locking joints and comparing parameters originally listed all variants walk.
The blockage was assured of all joints, knee and ankle then right foot (left foot free from constraints).
In the first case, knees locked, so if gait cycle began with the left foot and the cells start with the right foot is noted that the force with which the subject gets on his left leg in normal walking is greater than the force of the subject when walking with right knee locked.
The difference in loading of the legs when walking normally healthy and the knee locked is represented in Figure 7.
This difference in power is because the subject tends to change the center of gravity to the left when the right knee is blocked. Force left foot female subject has a value of 366 N while driving with his right foot stuck. When male subject has blocked the leg strength of 491 N value, which value for a healthy walk should be in the range 570-590 N (according to its body weight). [9]
Calculation of dynamic load on the plantar surface of each leg can be calculated with the following relationship:

$$ST(\%) = \frac{\frac{PS_1 + PS_2}{2}100}{\frac{PS + PS_2}{2} + \frac{PD_1 + PD_2}{2}} \tag{1}$$

$$DR(\%) = \frac{\frac{PD_1 + PD_2}{2}100}{\frac{PS + PS_2}{2} + \frac{PD_1 + PD_2}{2}} \tag{2}$$

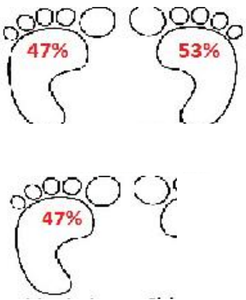

Image on pressure plate of right foot and left foot for Feminine subject

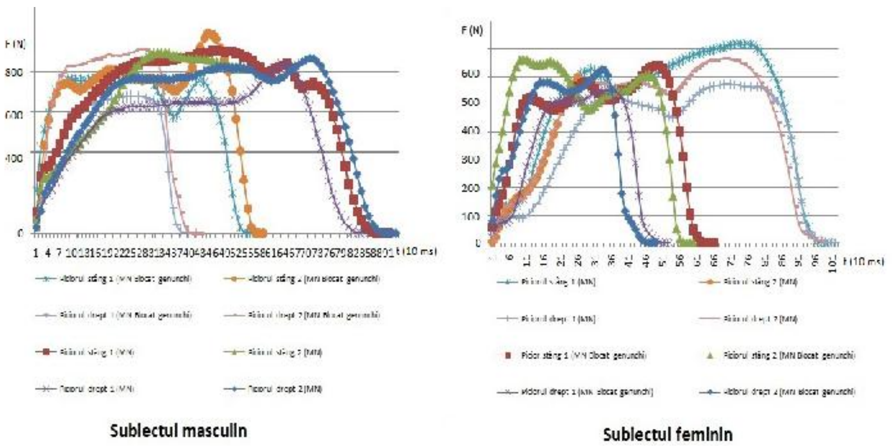

Figure 7: The plantar force distribution in normal gait with right knee locked

Walking type is the type of running march least affected by the fact that one knee is blocked because movement is executed with perfect knees stretched.
After planting measuring forces using RSScan pressure plate can say that plantar force developed by the two types of subjects in the two types of walking is different: strength in bottlenecks gait is less developed than in healthy walking.
As can be seen in Figure 8 plantar force difference occurs between left and right foot during walking with the knee locked.
In marching gait with knee locked leg shows a smaller force than in healthy marching gait. The right foot is much heavier than the left leg which indicates an inclination of the body to the right and discomfort during walking. [10]
Also moving subject with joints executed without constraints is faster than the bottlenecks knee.

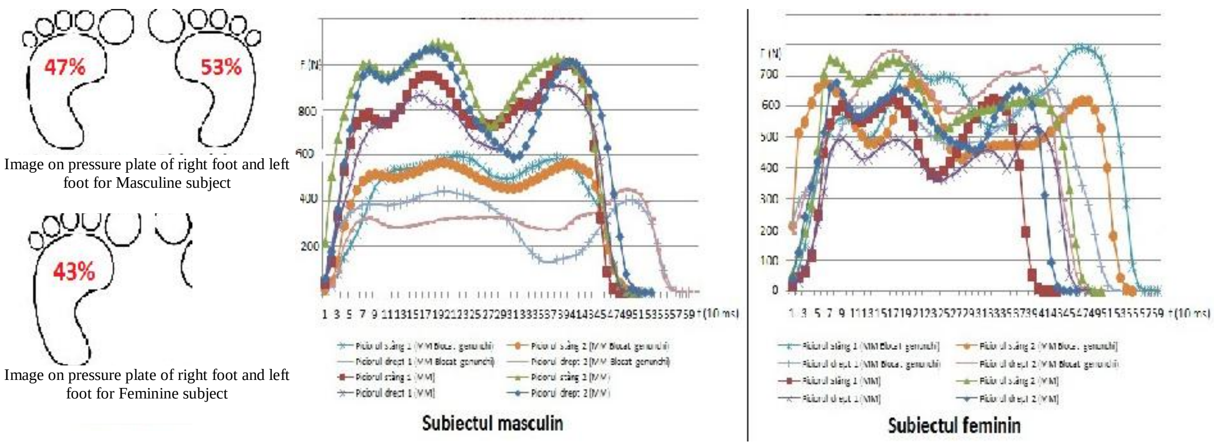

Figure 8: The plantar force distribution in march gait with right knee locked

Walking with ankle locked in the same procedure was performed (the same number of records on the same sequence of typologies walk).

Comparing walking to riding without blockages subject matter but with the man right ankle and jammed it can be seen as both a strength difference and a time difference distribution of motion. Plantar strength of the legs during walking with ankle block is greater than the force in driving without blockages. In Figure 9 can notice the difference in strength between the two plantar surfaces while walking with ankle lock: foot suffering a blockage develops a greater force than healthy leg.

As for making movement can be observed that subjects with producing member locked a move to shorter duration. When driving without blockages movement it is broader and the length is greater steps.

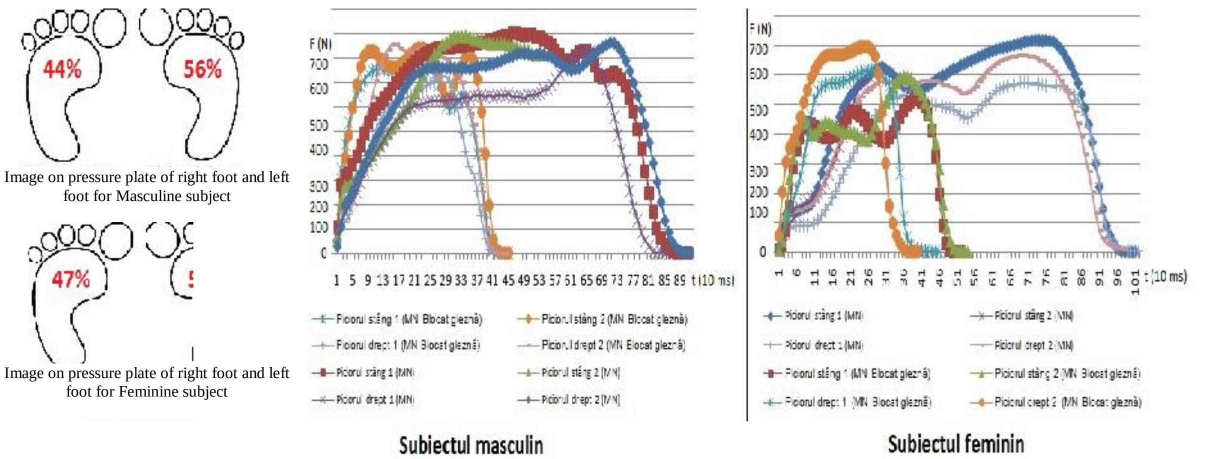

Figure 9: The plantar force distribution in normal gait with right ankle locked

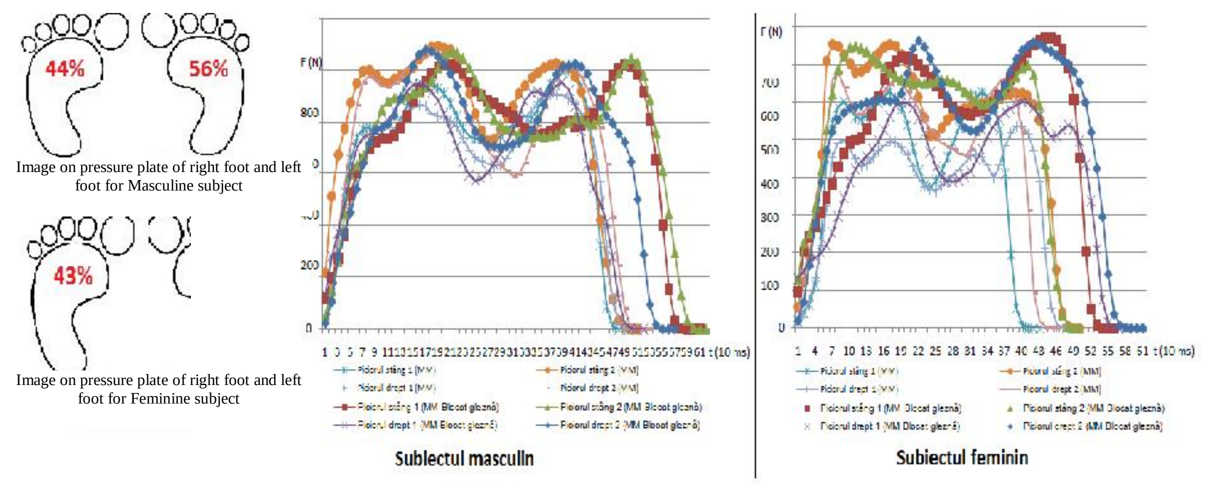

Figure 10: The plantar force distribution in march gait with right ankle locked

In march gait case the developed plantar forces of the two subjects it is different as value between healthy and walking at the ankle joint locked.
It can be seen in Figure 10 that the left leg force and right leg with blocked ankle in walking is greater than the force produced in healthy walking.
Analyzing the gait with locked joints that can be seen the right foot develop a bigger force than left leg both cases: male and female subjects.
Also Figure 10 represents the distribution of the force during walking marching ankle locked. The difference between left and right legs is relatively large the right leg is longer charge than the left.
This difference in loading produce an unbalanced gait where the right leg is used as a support while advancing left foot in length.
By comparing healthy walking (without blockages) and walking with blocked knee and ankle of right leg were obtained the following conclusions:
• The right foot is more loading during gait with locked knee than the left leg.
• Normal walking resembles with blocked knee gait by step added in stride length and strength in distribution;
• The momentum is greater on leg unblocked because it behaves more dynamically during action;
• If the knee is locked, up and down stairs is made cumbersome;
• Riding with locked knee is imbalanced;
• Force on the left foot and right foot during walking increases during the gait with knee locked than in gait without blockages;
• Normal walking gait with blocked ankle resembles with the gait with added step in the distribution strength and stride length;
• The right foot is more loaded during the gait with ankle locked than the left leg;
• The momentum (in the same sort of gait-ankle blocked) is greater on leg unblocked because it behaves more dynamically during operation;
• If the ankle is locked down stairs is heavy;
• Walking with ankle block is unbalanced;
• Forces of the left foot and right foot, during walking with ankle locked increases while gait without blockages;
In future researches will consider other dynamic parameters simultaneously typologies gait constraints on both joints of the right foot to track how plantar surface load and change the temperature.

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