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Manual Therapy in Diabetic Patients with Tibio-tarsal Dorsiflexion Deficit and Forefoot Overload: A Case Report

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ABSTRACT

Introuduction: Limitation of tibio-tarsal joint mobility in diabetic patients can occur within a few years of diagnosis, even in young patients. This joint movement deficit is believed to be due to stiffness in muscles, tendons, joint capsules, ligaments and skin. With this in mind, the aim of this study is to design an experimental protocol of orthopaedic manual therapy and therapeutic exercise in the future for subjects with diabetes, reduced joint mobility and subsequent insufficient dorsal flexion of the tibio-ankle, and to test the reduced avampodalic pressure that correlates with an increased ulcerative risk.

Case presentation: A patient aged 64, male, overweight, family history of type II diabetes, self-employedwith and diagnosed with diabetes type 2.

Results: The patient was evaluated with inertial motion sensors, Baropodometric platform, Lounge test, MWM. Already after the first session an improvement in plantar pressures was observed with a decrease both in the peaks from 413.6 Kpa to 99 Kpa in both feet and in the average plantar pressures from 129.8 Kpa to 54.5 Kpa for both feet with a decrease in plantar pressures at the forefoot from 43.7 % to 33.2 %. Tissue elasticity was assessed with the Lunge Test, and increased from 8 cm to 9.5 cm.

Conclusion: The results suggest that the role of manual treatment combined with an exercise programme could increase tarsal dorsiflexion and consequently decrease plantar pressures.

1. Introduction

The diabetic foot, is a condition characterised by anatomo-functional alterations caused by peripheral occlusive arteriopathy and/or diabetic neuropathy, that may favour the development of ulcerations.

The diabetic foot is a major and growing health problem that often leads to foot ulceration, lower limb amputation and increased mortality rates. The main aetiological factors of diabetic ulcers are neuropathy, vasculopathy and infection. However, there are many factors such as limited joint mobility, muscle weakness, gait abnormalities and foot deformities that together are responsible for the more or less early development of increased pressure at the foot level, leading to a serious ulcerative risk both in the short and long term (Anon n.d.-a).

Diabetic patients have been found to have muscle weakness, balance deficits and reduced mobility in the ankle, sub-astragalic and first metatarsophalangeal joints that interfere with normal foot rocker during gait, leading to abnormalities in walking. These factors may also alter the normal distribution of plantar pressures and thus lead to an increased risk of foot ulceration. Specifically, limitation of tibio-tarsal joint mobility in diabetic patients has an insidious onset, followed by progressive asymptomatic deterioration. This limitation may occur a few years after diagnosis, even in young patients. At the same time, it is known that there is a significant correlation between the range of motion of the foot and ankle joints. It is believed that this joint movement deficit is due to stiffness in muscles, tendons, joint capsules, ligaments and skin (Collins, Teys, and Vicenzino 2004; Hidalgo et al. 2018; Marrón-Gómez, Rodríguez-Fernández, and Martín-Urrialde 2015; Mason-Mackay, Whatman, and Reid 2017; Zordão et al. 2021). There are also important relationships between polyneuropathy and muscle weakness, as both result in reduced strength and muscle atrophy in the lower limbs. The association between type 2 diabetes and loss of strength and quality of movement in the lower limbs has recently been demonstrated, resulting in early disability and worsening the patient's quality of life (Apelqvist et al. 2008; Boulton et al. 2008; Fernando et al. 1991; Mueller et al. 1989; Sacco et al. 2009; Zimny, Schatz, and Pfohl 2004). With this in mind, the aim of this study is to observe whether orthopaedic manual therapy and specific exercise for subjects with diabetes mellitus can lead to an increase in joint mobility with a subsequent reduction in plantar pressures.

2. Materials and Methods

2.1. Case presentations

The 65-year-old male subject suffers from diabetes mellitus type II diagnosed about 5 years ago, and lives in the city of Bologna. He has a bilateral dorsal flexion deficit that makes his walking less efficient and certainly more physically demanding. The subject has a family history of diabetes, and his therapy consists of taking oral hypoglycaemic drugs; he underwent successful total coxofemoral joint arthroplasty surgery in January 2018. Th subject signed a standardised informed consent.

Timeline: Patients with a medical diagnosis of Diabetes Mellitus at

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the Istituti Ortopedici Rizzoli in Bologna will be enrolled.

The patient will be selected on the basis of the following inclusion criteria: 1) age equal to or greater than 18 years; 2) subject able to walk independently or with minimal assistance for a distance of 10 metres; 3) current orthotic foot therapy.

Exclusion criteria: 1) presence of ulcerations 2) presence of dementia based on the Mini-Mental State (corrected score < 27); 3) orthopaedic complications or Charcot foot; 4) history of epilepsy; 5) any therapeutic treatment that modifies cognitive or motor performance; 6) history of depression or other psychiatric disorders; 7) moderate degree Sensitive Neuropathy at the monofilament test.

Written informed consent will be obtained from the patient.

The patient will be evaluated with the Lunge Test to assess the stiffness of the compartment, digital inclinometer to check the limitation of dorsal Tibio-Tarsal flexion, which must be less than or equal to 10°. Subsequently, a Baropodometric Footboard will be performed, where plantar pressures will be recorded, and sensors will measure parameters such as gait speed and cadence to note significant differences.

2.2. *Apparatus and task*

MWM - mobilisations with movement: Is the concurrent application of sustained accessory mobilization applied by a therapist and an active physiological movement to end range applied by the patient. Passive end-of-range overpressure, or stretching, is then delivered without pain as a barrier.

Baropodometric footplate: The baropodometric platform is an instrument used in the clinical field and allows the quantification of plantar pressure both during walking and in static conditions. The parameters that can be obtained from the baropodometric platform by means of specific software are many. Maximum pressure peaks are defined as the maximum pressure values recorded for each sensor and are expressed in kPa. From their distribution in space, a footprint is constructed from which it is possible to obtain information of clinical value regarding the morphology of the foot, average pressure on each sensor; this image can be an indicator of the parts of the foot that touch the ground during walking (Yumpu.com n.d.).

In this case, a reduction in plantar forefoot pressure after treatment was observed as a consequence of an improvement in dorsal ankle flexion.

WIVA Motion Sensors: In this study, a tool called Wiva Science. Il Wiva Science is a motion analysis device based on the use of inertial sensors and the wireless transmission via Bleutooth of the acquired data to the associated smartphone, which is also made visible in real time on the PC. Walk or run analysis with the system Wiva Science enable easy field assessments for any healthcare professional. The sensor is positioned by means of a specific elasticated belt on the patient's lower back at waist height, particularly at the level of the L4-L5 vertebrae. The fastening should be as rigid as possible to avoid unwanted oscillations that could compromise data collection and thus functional testing (Anon n.d.-b).

Lunge Test: This test has proven to have very good reliability/repeatability (Bennell et al. 1998) and prospective studies have also shown that it is predictive of injury (Gabbe et al. 2004; Pope, Herbert, and Kirwan 1998).

The Lunge Test is a quick and convenient test used to “determine dorsiflexion ROM” in a weight-bearing position (closed Kinetic chain).

2.3. *Procedures*

The study involves the evaluation of manual treatments, which are routinely performed by a physiotherapist, on a subject with diabetes mellitus. The patient will perform for 4 weeks twice a week, Mondays and Fridays, a manual antero-posterior translation technique, MWM Technique, of the talus on the tibia on a couch in the cavalier servente position for 10 repetitions for 3 sessions with 1 minute break between each session bilaterally. An exercise, squats in orthostatism with heel on the ground, to be performed on non-treatment days, always 3 sets of 10 repetitions twice a day, will be proposed. After four weeks the subject will be re-evaluated. In the second month the subject will continue for a further month with self-treatment only; after this period the subject will be assessed again.

Every Monday for four Mondays of treatment he/she will be assessed with Lunge Test, Baropodometric Footboard and inertial movement sensors over 10 m to see speed and step cadence. It will be repeated after the month of self-treatment only.

3. Results

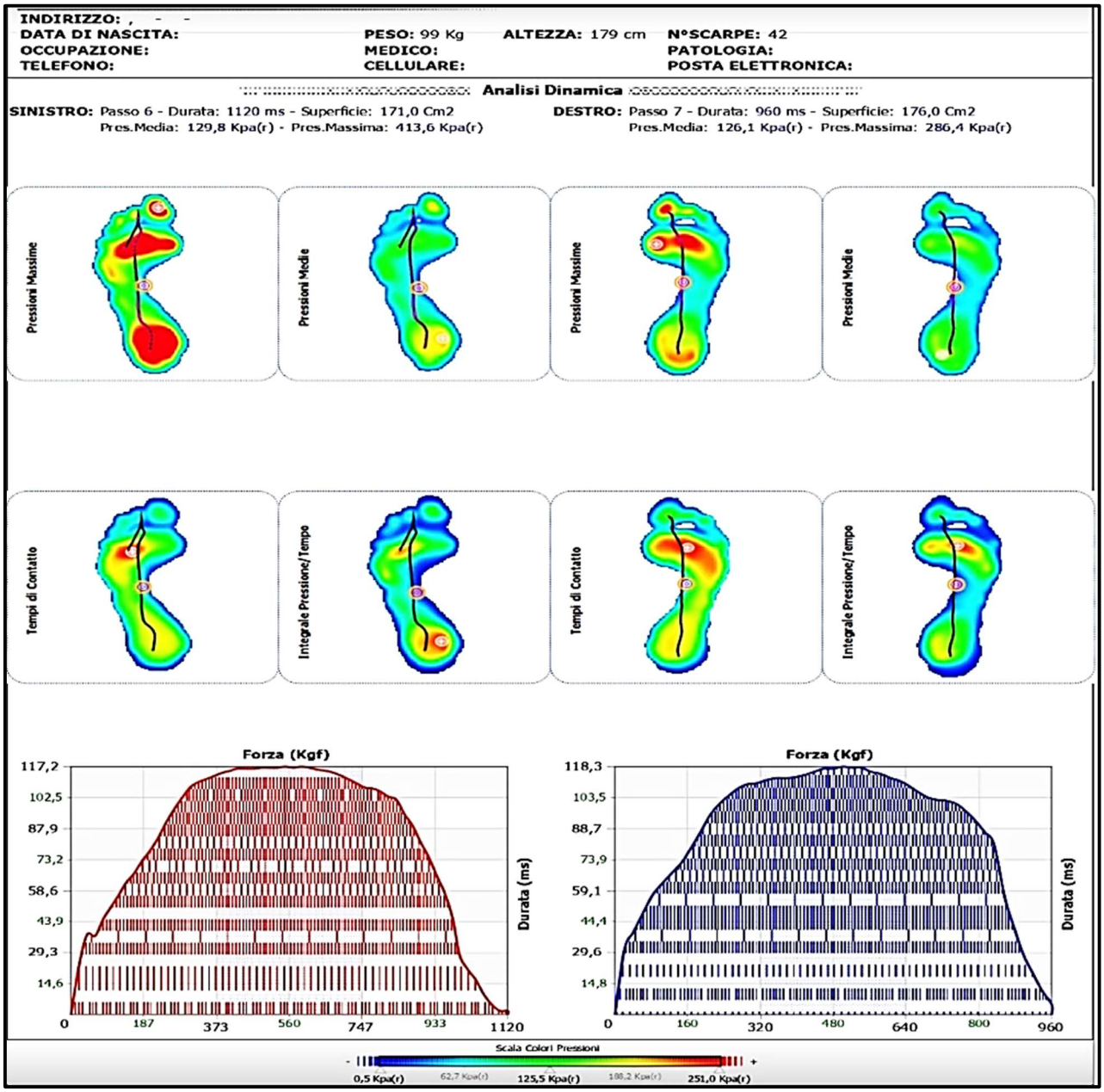

Figure 1. Baropodometric footplate: Describes how forefoot pressures before treatment were greater.

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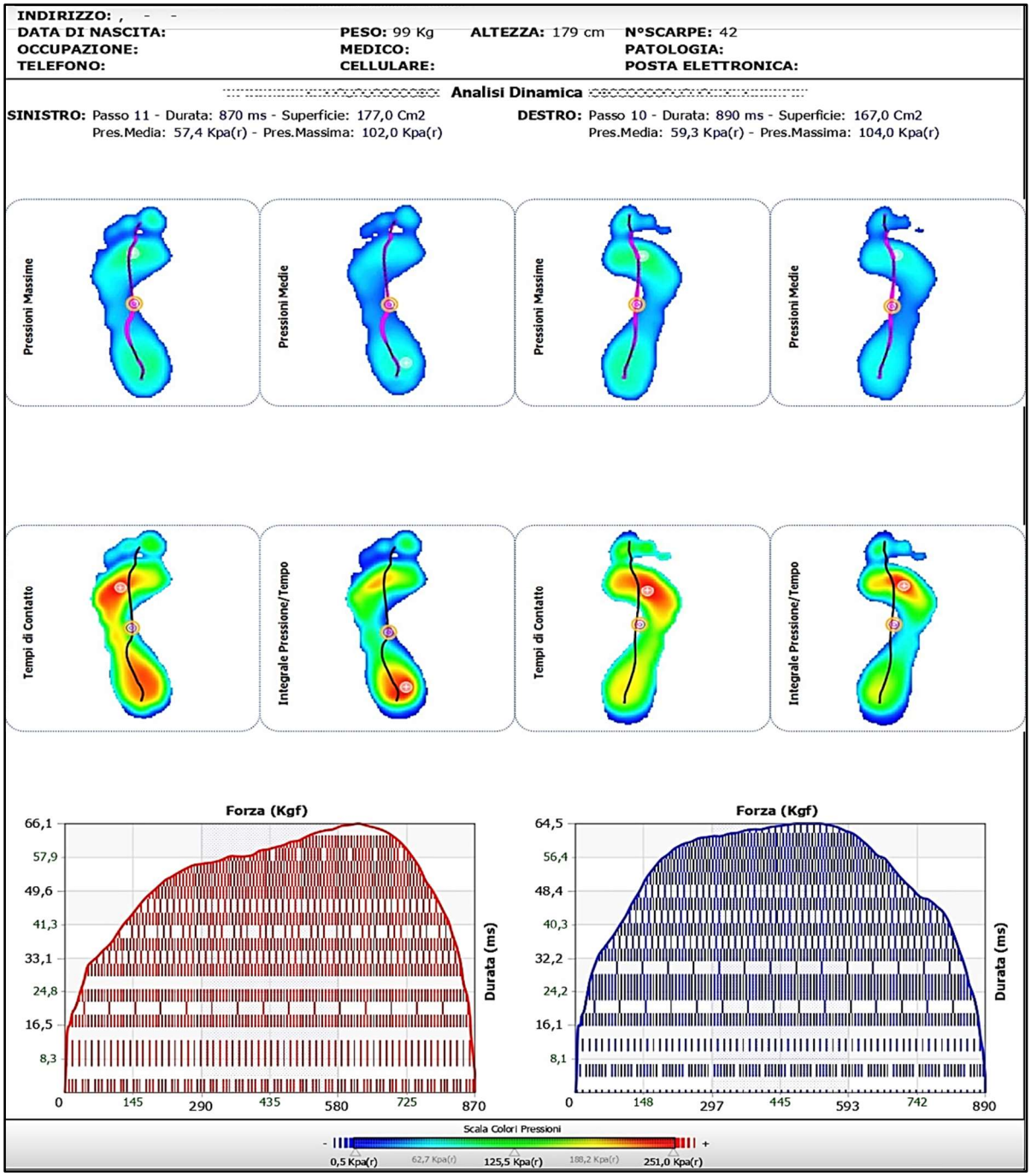

Figure 2. Baropodometric footplate Describes how pressures in the forefoot after treatment had decreased.

Table 1. Pressure data before and after treatment measured with the baropodometric platform, improvement on the lunge test and speed and cadence measured with Wiva sensors.

	T0	T1	T2	T3
Pressure max sx	413.6 Kpa (r)	99.0 Kpa (r)	100.0 Kpa (r)	102,0 Kpa(r)
Pressure MD sx	129.8 Kpa (r)	54.5 Kpa (r)	57.6 Kpa (r)	57,4 Kpa(r)
Pressure max dx	286.4 Kpa (r)	99.0 Kpa (r)	97.0 Kpa (r)	104,0 Kpa(r)
Pressure MD sx	126.1 Kpa (r)	56.0 Kpa (r)	56.2 Kpa (r)	59,3 Kpa(r)
Lunge test sx	8cm	9cm	9cm	9,5cm
Lunge test dx	8cm	9cm	9cm	9,5cm
Speed	83.8 m/min	81.1 m/min	82.4 m/min	82,6 m/min
Cadence	56.0 steps/in	53.6 steps/in	54.0 steps/in	53,8 steps/in

Note: Lounge Test regular values ≥ 10 cm; Speed regular values 77.4±9.48 m/min; Cadence regular values 52.8±3.8.

4. Discussion and Conclusion

Limited joint mobility and reduced tissue elasticity are very common in diabetic patients, even in the absence of complications. These characteristics may explain the difficulties diabetic patients have in performing physical activities with the subsequent development of additional functional impairments. In the presence of reduced dorsal tibio-tarsal flexion, the foot is unable to properly deliver shock absorption on contact with the ground and may lose the ability to maintain normal plantar pressure (Giacomozzi et al. 2002; Rao, Saltzman, and Yack 2010; Sawacha et al. 2009). This effect can facilitate trauma in the plantar surface and eventually lead to foot ulceration. In this context, therapeutic exercise has always been considered an important component of prevention and therapy; in contrast, the effect of orthopaedic manual therapy has never been explored. There is evidence to support that regular physical activity can play a role in the primary and secondary prevention of several chronic diseases, including diabetes (Francia et al. 2018).

In line with these observations, our results show that a period of 8 weeks of manual therapy and therapeutic exercise, adapted to the condition of the subject, are able to improve the mobility of the ankle joint. Already after the first session, an improvement in plantar pressures was observed with a decrease in both peaks from 413.6 Kpa to 99 Kpa in both feet; but more importantly, the results of the average plantar pressures also improved significantly from 129.8 Kpa to 54.5 Kpa for both feet with a decrease in plantar pressures at the forefoot from 43.7 % to 33.2 %. Tissue elasticity was assessed with the Lunge Test (Cejudo et al. 2014; Powden, Hoch, and Hoch 2015; Williams, Caserta, and Haines 2013), which measures the stiffness of the gastrocnemius-soleus complex by measuring the dorsal flexion of the tibio-tarsus under load, increased from 8 cm to 9.5 cm, albeit with data that are not yet optimal to make the test good (the normal range is > 10 cm). Gait performance with inertial motion sensors did not change significantly, perhaps also due to the short time of the study. It is evident that the decline in the musculoskeletal form of diabetic patients, which often results in disability, may be reversible. The improvement we saw in our study in the patient(s)' performance after orthopaedic manual therapy combined with exercise can improve their ability to meet the demands of daily life and allow them to maintain functional independence. Our study also demonstrates the effectiveness and feasibility of an exercise programme for diabetic patients associated with manual therapy, suggesting that such programmes should be suggested as routine therapy in this type of patient.

The diabetic patient is a subject with frequent comorbidities and from the ulcerative point of view, especially in the foot, risks over the years to develop secondary complications such as the diabetic foot which is strongly correlated with ulcerations and subsequent amputations.

The role of manual treatment associated with an exercise programme under the supervision of a physiotherapist, an education in continuous specific exercise to increase tibio-tarsal dorsi-flexion and reduce forefoot pressures, may be essential for subjects who, after an adequate training programme, become capable of performing physical activities independently (Lepesis et al. 2022; Searle et al. 2017).

Although this case report is only a descriptive study, it lays the foundations for further studies of treatment efficacy, in order to include specific manual therapy in the treatment of diabetic patients with a view to improving quality of life.

Conflict of interests

The authors report no declarations of interest.

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