THE INFLUENCE OF VISCO-ELASTIC INSOLES ON GROUND REACTION FORCES DISPLAYED BY ACHILLES TENDONITIS PATIENTS

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INTRODUCTION: Our experience has shown, particularly in medical activity in the field of sport, that the practice of certain sports presents important risks of developing various pathologies of the lower limbs, disorders which may also occur in sedentary subjects. The present paper focuses on the problem of inflammation of the Achilles tendon; a pathology that is commonly observed in athletes, especially those involved in all fields of athletics. Inflammation of the Achilles tendon is rarely cured without specific therapy, since mere walking or standing imposes continuous stress on the inflamed tendon, as well as the whole system connected to it. Our treatment has provided encouraging results in this type of tendonitis, also with regard to the subject resuming the practice of the sport and, in general, concerning 'intensive' use of the tendon, subsequent to treatment of the acute phase of the pathology. We will examine in particular the loss of function that may be induced by this condition in the act of walking, when all the forces involved in the interaction between ground and foot are freed with the movement of dorso-plantar flexion in the context of the ground-foot reaction. The aim of the study was to compare the pattern of the ground-foot reaction in a group of subjects affected with inflammation of the Achilles tendon, evaluated in the acute phase of the pathology, during treatment and after it, with a group of 'normal' subjects, that is, with a normal gait, to quantify the functional deficit and the recovery of normal function by treatment with personalized visco-elastic insoles.

MATERIAL: The ground-foot reaction was evaluated in 19 affected subject runners, (7 with bilateral pathology), in a total of 26 affected limbs. The patients were aged 19-63 years (mean age 35); 4 were female and 15 males. In all cases the pathology in the tendon was to be put in causal relation with their sport activity.

METHOD: The first set of evaluations was made during the acute phase of tendonitis as confirmed by ecography. The subjects underwent computerized gait analysis on a dynamometric platform, walking at their 'natural' speed on a 16-meter-long footboard on which a 400 mm x 600 mm Bertec dynamometric platform was placed after 2/3 of the walk. The dynamometric platform is an apparatus designed to measure the force a subject exerts while walking on top of it; according to Newton's Third Law, this force is equal and opposite to that exerted physically by the platform to stay rigid (ground-foot reaction) while supporting the weight pressing on it. In fact, this force, as well as its variation in time and its direction, can provide important information regarding how a subject walks; the qualitative and statistical evaluation of the forces exerted during walking on the platform constitutes the 'gait analysis'. For every evaluation, 10 measurements were made and results obtained were statistically analyzed to calculate the mean value and standard deviation, which were used as significance values for each foot. Possible

'normalization' of the patterns of the ground-foot reaction with respect to the initial evaluation was verified by means of the Student's 't' test. The gait analysis was planned as follows:

1) The first series of measurements was made with the subject first barefoot and then wearing flat, comfortable shoes (gym-shoes), also to assess any help given by the shoe to the affected limb, a factor which is known to almost always determine a normalization of pattern.

2) The gait analysis was then repeated 10 days afterwards, i.e., during the treatment of the tendonitis by elastic plantar insoles, subsequently combined with laser-therapy (LASER at 780 nm); this time the subject underwent analysis first barefoot, then wearing shoes and, lastly, in shoes equipped with insoles. The mean duration of the insole treatment was 12 weeks (8-25 weeks).

3) 18 months, on the average (12-24 months), after the end of the treatment, the patients were recalled. This last series of evaluations was undergone barefoot and then in shoes. In addition, the R.o.M. of the affected and non-affected tibio-tarsal joints was measured by electro-goniometer in all patients on the occasion of the first gait analysis, 45 days after starting insole treatment and at re-evaluation 18 months after the end of the therapy. The force measured by the dynamometric platform is usually resolved in 3 components in the following directions: vertical (Fz), antero-posterior (Fy) and medio-lateral (Fx); the vertical component is generally considered to be the most explicative and reproducible concerning the interaction between foot and ground.

RESULTS: The evaluation of the R.o.M. of the tibio-tarsal joint of the affected side showed an initial decrease to 90 degrees (in the acute phase of the pathology) in all cases, while the unaffected limb presented a normal outward movement. 45 days after starting insole therapy no increase was seen in the R.o.M. of the affected limb. At final evaluation, 18 months after the completion of therapy, the R.o.M. was increased, on average by 8 degrees. This section will show the results of the numerical and statistical analysis of the data regarding the ground-foot reaction obtained on the platform before, during and after visco-elastic insole treatment, barefoot, in shoes and in shoes plus insoles. In this analysis, priority was given to the data of the vertical component, which is the most explicative and reproducible concerning the interaction between foot and ground. The anterior-posterior component was also evaluated:

1) The results of the tests with bare feet in the acute phase of the pathology (initial phase) showed these values to be the most different from the normal pattern. The pattern of the vertical component presented an alteration in parameters F1 and F3 (too weak or too strong) to an extent varying from 5 to 15% (mean value 8%) as shown in Table 1. The pattern of the antero-posterior component confirmed the finding emerging from the vertical component, both for the phase with the heel in dorsi-flexion (which in the pattern of the vertical component is placed in relation to the percentage value of F1 and in the pattern of the antero-posterior component to F5) and for the phase of advancing and transferring the weight onto the forefoot in dorsi-flexion (which in the pattern of the vertical component is placed in relation to the percentage value of F3 and in the antero-posterior component to F6). We thus observed a below-average (lower) F5 value in the cases also presenting a below-average (lower) F1 and an above-average (higher) F5 value where there was an above-average (higher) F1. The same applied to the relationship between F6 and

F3; an above-normal F3 is associated an above-normal F6 and a below-normal F3 is associated with a below-normal F6. The data obtained with shoes in the first evaluation showed a mean improvement of 1.5% in both components (vertical and antero-posterior), in that the numerical deviation of the parameters from normal values is limited compared to the values for bare feet (see Table 2)
2) The tests with shoes plus insoles 10 days after the start of treatment also showed an improvement of 2.5% on average (see Table 3); the patients already presented a general improvement in this phase regarding pain and general functionality.
3) The same can be seen for the evaluations 18 months after the end of treatment; a gradual recovery can be observed in the abnormal values, always considering the F1 value (in relation to F5) and the F3 value (with F6), so that in the end these parameters, while following the same general pattern seen in the first evaluation (below or above normal), showed a mean alteration of 4% (see Table 4).
4) The pattern of the medium-lateral component in these subjects was seen to be very irregular, with frequent changes in the direction of the force exertion, between middle and side, and didn't correspond to normal gait (in literature).

CONCLUSIONS: It should first of all be noted that during inflammation of the Achilles tendon in subjects, the particular features emerging of the exertion of force (as evidenced by the pattern of the components), which are individual to every subject, become accentuated. It mainly involves an unbalance in the exertion of force on the ground with the heel or the forefoot which may be either too weak or too strong. Regarding the results of the personalized visco-elastic insoles therapy, a progressive reduction of up to 4%, on average was observed in the deficit of the numerical value recorded (also in the tests, 18 months after the end of treatment, with the subjects barefoot or wearing shoes without insoles). The disappearance of pain should be correlated to the following:
1) normalization of the interaction between foot and ground, which occurs during treatment with the subjects wearing the insoles continually;
2) the best possible spatial alignment of the foot-ankle complex, particularly the rear-forefoot system, also as a consequence of the anatomo-functionally personalized visco-elastic insoles.
This therapeutic approach in inflammation of the Achilles tendon is undoubtedly to be considered beneficial; the fact that this condition occurs in subjects who already have a predisposition for this pathology, as a result of the manner in which they exert force on the ground, suggests that appropriate shoes and specific visco-elastic insoles should be worn continuously during physical exercise by subjects with a habit of exerting particular force on the tendons and connected structures, in order to prevent the onset of this pathology or recurrence of its acute phase.

TABLE 1 First evaluation, barefoot

Parameter	Change (comp. to normal)	**Mean change**
F1 (with F5)	5-15%	**8%**
F3 (with F6)	6-15%	**7%**

TABLE 2 First evaluation, with shoes

Parameter	Change (comp. to normal)	**Mean change**
F1 (with F5)	5-13%	**6.5%**
F3 (with F6)	6-13%	**5.5%**

TABLE 3 Evaluation with shoes + insoles (after 10 days' treatment)

Parameter	Change (comp. to normal)	**Mean change**
F1 (with F5)	5-11%	**5.5%**
F3 (with F6)	6-11%	**4.5%**

TABLE 4 Evaluation barefoot or with shoes (18 months after end of treatment)

Parameter	Change (comp. to normal)	**Mean change**
F1 (with F5)	5-11%	**4%**
F3 (with F6)	6-11%	**4%**

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