“Foot strengthening” – Improving the missing link by a stronger approach

Has an athlete ever told you they suffered from “DOMS” after your foot exercises? I could count mine on the fingers of my hand before I started to question myself: Do I really strengthen his/her feet? Since I’ve addressed this issue by using an evidence-based practice (biomechanical & neurophysiological studies) and practice-based evidence approach (clinical reasoning & experience). This has vastly improved my exercises prescription when my goal was developing foot strength during rehabilitation (injury) or athletic development process (performance).

It makes sense for many people (e.g. coach, S&C, physio) that the human foot complex is the underestimated link of the kinetic chain and in my experience can be the limiting factor when examining explosive tasks such as sprinting, cutting or jumping. However, when looking at the research and conferences or online discussions around this area, many training programs overlook (in the set, reps, intensity, settings) this basic principle: “the foot is a load bearing structure that copes with forces exceeding body weight”. I am even surprised to see much enthusiasm/interest in toe yoga or theraband exercises to strengthen the foot that I have the impression that we want hands instead of feet. But we will come back later in this article to explain why this kind of exercise is perhaps not the most relevant for training the foot muscles from a neurophysiological point of view.

At La Tour Hospital (Swiss Olympic Medical Center) in Geneva, where I am the lead clinician for foot and ankle rehabilitation, I use what I call a “strong approach” to strengthen the foot in comparison to the current “light approach” taking into consideration this magnitude of forces encountered within the foot during locomotion (Figure 1). In parallel to this clinical work, I’m also currently involved in a PhD around the role of the foot muscles on sport performance with some promising initial results.

CURRENT FOOT STRENGTHENING PROTOCOL (rehabilitation oriented)	LTH FOOT STRENGTHENING PRINCIPLES (rehabilitation & performance oriented)	CURRENT FOOT STRENGTHENING PROTOCOL (performance oriented)
Emphasis on intrinsic foot muscles	Emphasis on intrinsic foot muscles & toe flexors muscles	Emphasis on toe flexors muscles
Exercises focus on arch control (eg. short foot) or toes coordination (toe spread-out)	Exercises focus on midfoot stiffness and forefoot strength	Exercises focus on forefoot strength
No specific resistance load targets (theraband ++)	Isometric resistance load	Isometric or isotonic resistance load (in kgs) on a custom device
Exercise’ position : sitting, bipedal or unipedal in progression	Exercise’position : standing with additional load relative to body weight in progression	Exercise’ position : sitting with no progression
Exercise’ prescription: 3x10-15 reps with no mention of volume or intensity	Isometric strength training principles: hypertrophy or max force (volume/intensity)	Maximal/submaximal iso-metric/-tonic contractions with no mention of volume

<u>Figure 1</u> : La Tour Hospital (LTH) foot strengthening principles in comparison to actual foot strengthening protocol

1 Is dedicated foot strengthening a worthwhile time investment?

Foot-ankle complex: more than the ankle plantar flexors

We all know that the ankle and especially the plantar flexors are key contributors to sport performance and play a critical role in accelerating the body rapidly during sprinting[1,2], cutting[3] or jumping[4]. However these assumptions are based on an over-simplified rigid foot model (with no deformation) leading to an over-estimation of ankle power, while simultaneously underestimating the power generated by the structures within the foot[5]. The role of ankle plantar flexors power is as important as the capacity of the foot structures to resist deformation for efficiently promoting the power transfer during push-off[6]. This underpins the concept of force production (the motor) and force transmission (car transmission systems and wheels). We frequently notice massive athletes with big muscles and overall power generation capability losing power and energy around their distal complex each time they push to the ground. Whatever your lower limb (hip, knee, ankle) power generation capability, if your foot system is not able to 'transfer' that power output into the ground and "deforms" under tension, this will impair your technique, mechanical "effectiveness" – and in turn your acceleration performance.

Human foot complex and locomotion

The human foot is complex structure with multiple joints and muscles that must deal with stiffness and compliance depending on the task : therefore it is not a rigid structure. Among all these joints the medial longitudinal arch (MLA) is a key structural feature. It provides the foot with the necessary stiffness to act as a rigid lever, but it must also be sufficiently flexible to function like a spring to store and release mechanical energy and allow mechanical energy conversion[7]. Likewise, the metatarsophalangeal (MTP) joints located in the forefoot are fundamental to absorbing energy (via toes dorsiflexion) while power is generated simultaneously at the MLA during the stance phase[8,9].

This biomechanical coupling between these 2 joints via energy transfer is enhanced by the foot muscles: the intrinsic foot muscles (IFM) with origin and insertion within the foot and the extrinsic foot muscles (EFM) with origin outside the foot and insertion within the foot. During the push-off phase, the IFM together with the extrinsic foot muscles toes flexors ($EFMT_f$) work as functional groups to stiffen the MTP enhancing our ability to generate propulsive power[10,11]. Interestingly, we know that removing the capacity to activate the IFM alters the leverage function of the foot and ankle joint moment production during propulsion and in turn vertical jump performance[12].

Forefoot strength and performance : past research

Sports performance in some actions is often linked to the ability of athletes to produce high amounts of ground reaction forces (GRF) over short contact time periods in the vertical, medio-lateral or horizontal directions[4,13,14]. Although the moment produced by the MTP joint is smaller than the other lower-limb joints, the midfoot and forefoot are the only link between the body and the ground to transfer this high amount of GRF rapidly. The importance of strength around the forefoot has been argued for enhancing performance. Previous researches have shown that toes flexors strength (IFM & $EFMT_f$) is moderately correlated with performance during a 50-m sprint run, pro-agility test, 3-cone tests and different vertical jumps[15–17]. Furthermore, increased strength of the IFM & $EFMT_f$ is associated with better sprint and horizontal jump performance rather than vertical jump performance[18–20] This suggests foot strengthening can have an effect on horizontally-oriented explosive movements rather than vertical-oriented ones.

Forefoot strength and performance: ongoing research

If these studies could provide arguments to invest time on foot strengthening caution is needed before drawing definitive conclusions. Therefore, we were curious with JB Morin (PhD supervisor) to clarify the association between foot strength and specific kinetics underlying sprint performance (eg. vertical or horizontal impulse) on one hand, and the overall (multifactorial) performance itself (sprint or COD time, jump height or jump length) on other hand. With this in mind, we are currently working on a cross-sectional study investigating the association of MPT joint plantarflexion isometric strength, MTP rate of force development (RFD), calf and quadriceps isometric strength on sprinting, cutting and jumping performance kinetics. in healthy high-level athletes in 5 different sports: soccer, basketball, handball, rugby, and track and field. For sprinting, the preliminary analysis on 40 athletes with backward multiple linear regression showed that during medium acceleration (7th to 10th step), 33% of the variation of vertical net impulse can be explained by foot strength alone whereas 45% of the total force production can be explained by foot strength and RFD (0-250ms). During low acceleration (max speed) phase, 50% of the variation of contact time, 33% of horizontal impulse and 45% of total force production can be explained by foot strength alone. During anticipated cutting at 90°, 25-30% of the variation of vertical, medio-lateral and horizontal force production could be explained by foot strength alone. Interestingly, during vertical & horizontal countermovement jump we found no significant correlations. Knowing that many sport-related actions occur within a high ground reaction force (GRF) - low contact time context, these preliminary results highlight the potential interest of forefoot strength particularly in sprinting for enhancing the ability to produce high amounts of GRF over short contact time periods: force production => force transmission.

2 How to assess the individual need for foot strengthening?

Forefoot strength assessment

As for all good physical performance or rehabilitation programs, we should start with the mindset that we cannot manage what we do not measure. But while robust methods for evaluating the strength of hip, knee or ankle muscle groups exist, evaluating foot muscles strength is challenging and IFM strength even more.

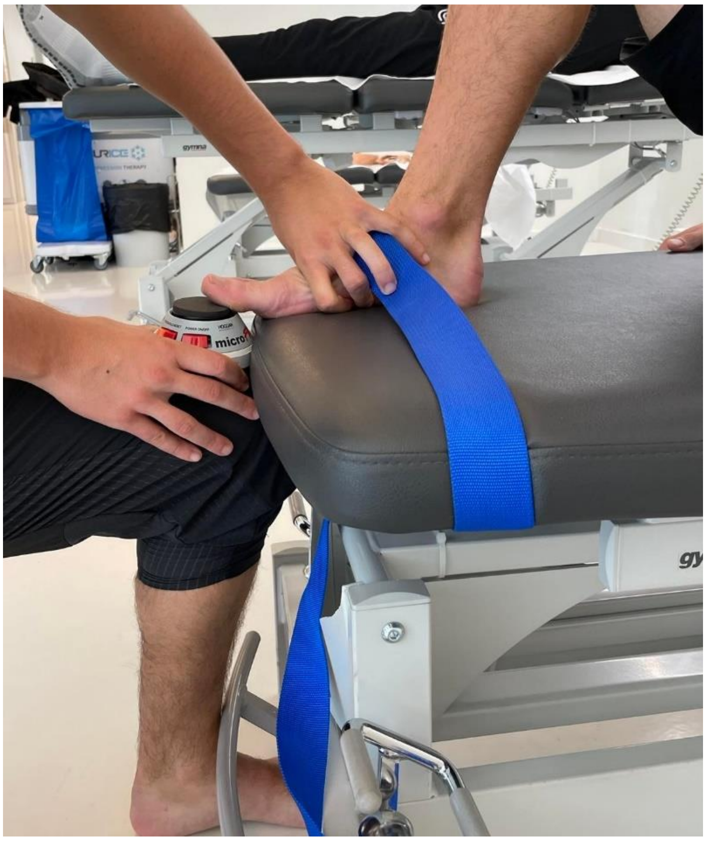
Recently, considerable efforts have been made in research to develop foot strength assessments focusing on different functional movement like toe gripping, toe pushing or doming and devices like custom-made ergometer, hand-held dynamometer (HHD) or pressure mat[21–26]. Considering this research, I'm currently using two ways to assess foot strength: a laboratory one and a clinical/practical one.

In our laboratory we have developed a custom-built dynamometer for isometric maximal plantarflexion strength of the MTP joint assessment (pre-positioned at 30° with the ankle in neutral position) (Figure 2). We chose this position for optimal force production of the IFM and the EFM regarding their force-length relationship[22,27]. Besides, the 3D forces sensor allows us to evaluate the MTP joint strength in pushing (vertical force), the MTP joint strength in gripping/curling (antero-posterior force) and the resultant (total force) between both. Total relative strength in this setting can measure maximal force around 520N (≈53kgs) and minimal force around 155N (≈16kgs). From our experience, a good value for total relative strength around the MTP in healthy male athlete is ~4N/kg.

<u>Figure 2</u> : Laboratory custom-built dynamometer evaluating MTP plantarflexion strength with a 3D forces sensor.

As many of us have experienced, taking the laboratory to the field is another challenge. In La Tour Hospital, I use a modified method of the one developed by Fraser et al.[25] to evaluate foot strength using a HHD (Figure 3). Because the structure of the 1st ray (hallux) is independent of that of the lesser toes as it uses different muscles to move, this testing evaluates the strength of both.

With the foot in ~20° plantarflexion and the MTP near neutral position outside the table, the subjects perform maximal isometric contraction by pushing their toes downward during 5 seconds. The different sensor size and shape of the HHD allows support behind the hallux or the lesser toes. A good relative strength value with this setting is ~2.7 N/kg for hallux (≈19kgs for an average person of 70kg) and ~2.2N/kg for lesser toes (≈16kg for an average person of 70kg). This given a hallux/lesser toes strength ratio of approximately 1.2-1.3 from experience in fully rehabilitated male and female athletes.



<u>Figure 3</u> : Clinical set-up evaluating toe flexion strength of the 1st ray with a hand-held dynamometer

To improve reliability of the measurement caution is needed with ankle plantarflexion compensation for some athletes. Therefore, putting a belt around the ankle in addition to a hand stabilization around the MTP head is recommended. For perfect isometric contraction an automatic (height adjustable) table should be used and the HHD should be put on the knee of the tester with his/her entire foot contacting the floor. If you want to focus on IFM in the assessment, putting the ankle in maximal plantarflexion allowing to increase their contribution in MTP strength flexion in regards to $EFMT_f$.

Midfoot strength/stiffness assessment

The single-leg heel raise test (SLHRT) is a commonly used clinical test to evaluate calf endurance capacity[28]. SLHRT performance is likely the product of ankle joint power and the muscles associated with it (gastrocnemius, soleus). However, it's also important to notice that midfoot/arch region power generation is also present during SLHRT, which influences performance[29]. This is due to the contribution of midfoot region active supports (EFM & IFM) elevating the arch during heel rise.

Interestingly, recent studies show that performing SLHRT with the toes in dorsiflexion (inclined plate) resulted in a greater amount of work generated at the midfoot region. This allows foot muscles to operate closer to their optimal length, at which they can exert maximal force to stiffen the arch[30,31]. A modified SLHRT with toes in dorsiflexion (25-45°) may be able to indirectly assess the strength around the midfoot region in addition to calf capacity.

For that, I use the same principle as SLHRT: performing maximal repetitions until exhaustion or technical failure with a cadence of 60 beats per minute guided by metronome. Over 33 repetitions for male and 27 repetitions for female athletes is a good measure of midfoot strength and calf capacity. Quality of movement should also be assessed during the test with a particular focus on: ankle aligned with the 2nd metatarsal ray, force distribution through the 1st ray, toes and MTP in contact with the floor and rearfoot supination.

VIDEO 1 : Modified single-leg heel raise test

3 How to develop foot strength in athletes?

Part 1: Considering the limitations of current foot strengthening programs

Through my years of interest around the foot-ankle complex, I have come to realize that current foot strengthening programs have a "light-approach" in their exercise prescription, even more when designed for athletes. Indeed, it is clear that they should use high-load resistance to strengthen maximally the hip, knee or ankle muscles, the comparatively low-load resistance used when strengthening foot muscles is concerning. Interestingly, a recent meta-analysis on rehabilitation-oriented studies showed no effect of IFM training on foot strength and muscle morphology (volume, thickness, CSA) questioning the strength training efficiency[32]. Here are my considerations around this limitation in current foot strengthening programs:

- **Problem n°1** : **"Do we wants hands instead of feet ?"**

Neurophysiological properties of muscles are closely linked to their biological function[33,34]. The ratio of motor units to physiological cross-sectional area (PCSA) for the abductor hallucis (AbH) appears quite low (Motor units: 43; PCSA: 6.6 cm^2) in comparison to similar muscles from the hand, such as the abductor pollicis brevis (Motor units: 136; PCSA: 1.6cm^2)[35–37]. These neurophysiological properties tend to reduce the ability of the IFM to precisely control gradation of force, therefore questioning the interest of teaching athletes to successfully perform different toe-posture or toe-yoga exercises. Given the magnitude of forces within the foot, their muscles are much more adapted to produce a high level of force in order to stiffen the forefoot for propulsion for example[38].

- **<u>Problem n°2</u> : "The foot is a load bearing structure why just sitting and standing ?"**

We've known for 70 years that there is no electrical activity of the IFM during quiet sitting and standing position as these muscles are recruited at forces exceeding bodyweight[39,40]. Since then, it has been demonstrated that activation of IFM increased with loading of the foot showing a load-fine tuning function[41,42]. However, it is disappointing to find no study (to my knowledge) using high-loading bodyweight (+%BW) while performing foot exercises. The basic progression is often: sitting, double leg stance and single leg stance position which is probably not beneficial for maximizing activation taking into consideration the previous points.

- **<u>Problem n°3</u> : "Okay brain, I believe we've had a problem here"**

We all know athletes who struggled to perform toes contractions. Also, 77% of healthy active people are unable to fully activate AbH (IFM) near its full capacity (>90%), which could be explained by its complex muscle morphology and/or a neural activation deficit[43]. Overcoming the inability for high voluntary activation is therefore an important training consideration in foot strengthening with neuromuscular electrical stimulation of the AbH being an immediately effective modality after just one single session for example[24,44].

- **<u>Problem n°4</u> : "3x10 reps is universal : same for the foot"**

The majority of current foot strengthening programs are composed of exercises performed over 3 sets of 10 reps or sometimes 3 sets of 15 reps or daily reps. In addition to the question: "why 3x10?", these programs also fail to give specific duration of contractions, intensity or volume of sessions and clear progression. We can unfortunately say that in comparison to other joints, the foot complex suffers from generic protocols that do not consider the fundamentals of resistance training: progressive overload, specificity, variation etc...[45].

The idea of this article is not to dismiss previous foot strengthening protocols but shift from these "light" generic protocols to a "stronger-approach" really improved my patient's rehabilitation and performance success as well as changed the athlete's perception on feeling the intensity and "burn" immediately during exercises. It's not because IFM and EFM are tiny muscles that they can't be overloaded.

<u>Part 2: Recommendations to improve foot strengthening exercises</u>

<u>Forefoot strengthening</u>

Considering the previous 4 remarks, my main exercise for global forefoot strengthening is performing in stance position (bipedal or unipedal) with a certain of amount body-overload (+%BW) where the athletes must push with their MTP joint against an inclined plate (Video 2). This tilt puts the MTP joint in dorsiflexed position and the IFM & $EFMT_f$ in an optimal position for force production regarding their force-length relationship around the ankle and the forefoot[22,27]. Following the session goal: maximal force or hypertrophy of foot muscles, the volume and intensity of the session that should be use is described in detail in Figure 4.

FOREFOOT STRENGTHENING

	POSITION	BODY-OVERLOAD	MOVEMENT	VOLUME	INTENSITY
MAXIMAL FORCE	Single leg stance (target a specific limb) 100% BW Double leg stance (target both limb) 50%BW	Progression : +60% to 120%BW (squat bar or kettlebell) Progression : +110% to 170%BW (squat bar or kettlebell)	Pushing isometric MTP joint flexion with toes in dorsiflexion position ↗ force capacity (force-length relationship)	Total: 60 to 80 seconds Rep duration: 3-5 seconds Example: 5x4x4s (8''/2'30) or 4x4x5s (10''/2'30)	Pushing isometric maximal action (PIMA) 80 to 100% MVIC ➢ NMES in addition can help max recruitment
HYPERTROPHY	Single leg stance (target a specific limb) 100% BW Double leg stance (target both limb) 50%BW	Progression : +30% to 100%BW (squat bar or kettlebell) Progression : +80% to 150%BW (squat bar or kettlebell)	Pushing isometric MTP joint flexion with toes in dorsiflexion position ↗ force capacity (force-length relationship)	Total: 140 to 220 seconds Rep duration: 7-10 seconds Example: 4x6x8s (6''/1'15) or 3x7x10s (8''/1'15)	Pushing isometric maximal action (PIMA) 60 to 80% MVIC ➢ body forward lean can ↗ arches tension

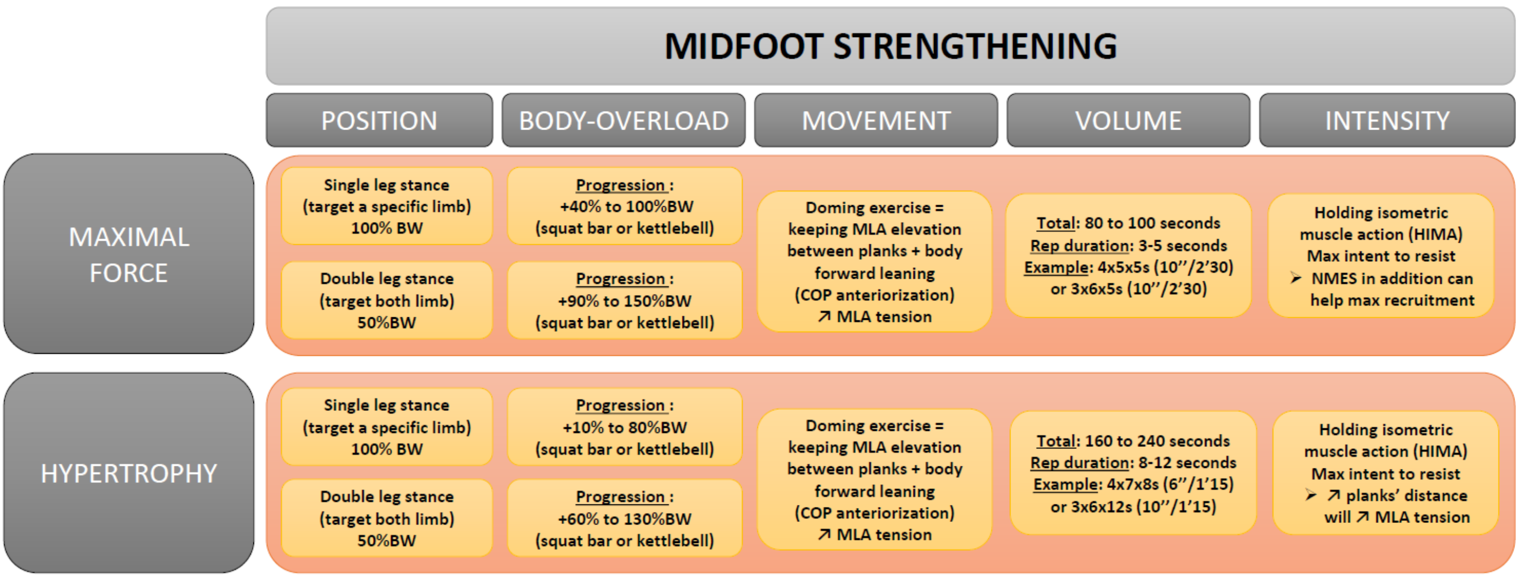
NB : 4x6x8s (6''/1'15) = 4 series of 6 isometric contractions of 8 seconds with 6 seconds of inter-repetition rest and 1min 15 seconds of inter-serie rest

Figure 4: Forefoot strengthening principles aiming at developing maximal force or hypertrophy of foot muscles (IFM & EFMT$_f$)

VIDEO 2: Mix of the different forefoot strengthening strategies

Midfoot strengthening

When focusing more on the midfoot region, I use what I called "foot-bridge" exercise to target the foot arches supports: tibialis anterior, tibialis posterior, fibularis longus, flexor hallucis longus and IFM. The goal of this exercise is to be in the same position than for forefoot strengthening (stance + body-overload) with the forefoot and the rearfoot region placed on planks or elevated supports. Being in this position causes the midfoot region to be overloaded by becoming passively unsupported. The athlete must then resist to midfoot collapsing by keeping an MLA elevation. Adding the instruction to lean the body forward leads to an anteriorization of the center of pressure (COP) above the midfoot region then increases the load under it. In addition to MLA loading, this exercise has also the vocation to target the transverse arch of the foot (the part of the arch that curves across the foot at the base of the metatarsal bones) which has recently been highlighted for playing a crucial role in increasing foot stiffness[46]. Like for forefoot strengthening volume and intensity of the session that should be use for maximal force or hypertrophy goal is described in detail in Figure 5.



NB : 4x7x8s (6''/1'15) = 4 series of 7 isometric contractions of 8 seconds with 6 seconds of inter-repetition rest and 1min 15 seconds of inter-serie rest

Figure 5: Midfoot strengthening principles aiming at developing maximal force or hypertrophy of foot arches supports

VIDEO 3: Mix of the different midfoot strengthening strategies

1st ray strengthening

As previously mentioned, the forefoot (MTP joint & phalanges) is the last link between the human body and the ground where the forces are the largest in the 1st ray in comparison to other parts of the foot[47]. This importance of the 1st ray for MLA stability and propulsion is mainly due to the flexor hallucis longus which has the largest volume of the deep extrinsic and intrinsic toe flexors (≈68 cm^3). Also adding the volume of the IFM dedicated to the 1st ray brought to a total volume of 119 cm^3 for 1st ray flexion in comparison to a total volume of 73cm^3 for the lesser toes flexion[48,49]. In relation to 1st ray assessment and the importance to have a stronger 1st ray than lesser toes (ratio 1.2-1.3) exercises aim at increasing the strength is then a necessity. In the following video, you can find two different types of exercise to target that: 1st ray elevation against leg-curl loading (eg. 100%BW) and 1st ray maximal isometric contraction with force-time curve biofeedback. Remember that the same principles described before should be applied in relation to volume, intensity or loading.

VIDEO 4 : Exercise streams for developing 1st ray strength

To give you a real-word example, you can find in the following figure the change of maximal plantar pressure (PP) distribution of a track and field athlete dealing with chronic foot injuries after 2 months of 1st ray and forefoot strengthening. As you can see, at the beginning of the process (1st picture) maximal PP was large around the 2nd and 3rd metatarsal heads which was linked to a 1st ray musculature weakness at that time: 2.1 N/kg (-30 % in comparison to the right foot). The 2nd picture taken 2 months later, and showed the increased PP under the 1st ray (MTP and phalanges) which was associated with an increase of her 1st ray strength: 2.6 N/kg (-8 % in comparison to the right foot).

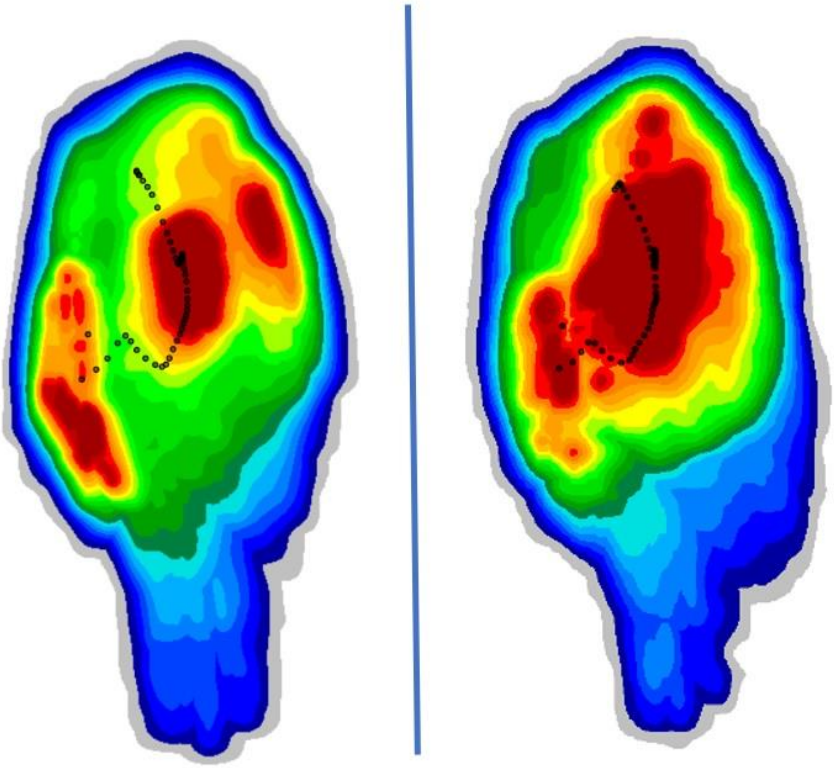


Figure 6: Example of the change of maximal PP during a high-speed running at 28 km/h after 2 months of forefoot and 1st ray strengthening on the left foot

Foot-ankle coupled strengthening

As previously mentioned, the importance ankle plantar flexors power is as important as the capacity of the foot structures to resist deformation and contribute to transferring this power during push-off[6]. This functional coupling between IFM and plantar flexors is fundamental and may be explained via a shared neural drive[7]. Therefore, in parallel to the previous exercises I like to incorporate exercises such as isometric ankle plantarflexion push-off, explosive heel-rise, pogo jump etc to enhance this mechanical coupling between foot and ankle. During all these exercises, I ask the athlete to focus on being stiff, avoiding foot collapsing and transferring force application on their 1st ray where I use different types of feedback (TheraBand, NMES, tape, inclined plate etc,). You can find some exercises examples in the following video.

VIDEO 5: Exercise streams for developing foot-ankle coupled strengthening

What about other modalities ? Plyometrics, minimalist footwear, etc

The aim of this article is to analytically review ways to strengthen the foot and how we can improve it. This does not mean other modalities are overlooked, but I believe that these principles should be the foundation when your goal is to strengthen the foot. I'm not a great fan (who is?) of recommending that you just need to go barefoot or do plyometrics to strengthen your foot. For sure it would be ideal to find a “one-size-fits-all approach” but as for the other joints it doesn’t exist for the foot complex. Therefore, in addition to these basics, I like to recommend micro-doses barefoot exposure during training sessions (warm-up, gym workouts) as it’s an interesting stimulus for foot muscles morphology. Concerning plyometrics training, we know that it’s a great stimulus for calf and foot complex but it persists a misconception that we have to do this kind of training only once the athlete has reached a certain level of strength. If some exercises could be too advanced for some weak athletes, plyometric training should be work in parallel to increase strength capacity of the distal complex. It may also be of interest to consider the biomechanical specificities of the absorption (unlocked foot joints and energy storage through pronation) and propulsion (locked foot joints and energy return through supination) phases in order to promote a more dedicated strengthening strategy for each. For instance, recommending sessions of double or single foot-ankle rebound jump on an everted or inverted inclined board (Video 6) appears a practical application of that principle mimicking both of these critical stance phases. In addition to this example of foot jump training, I advise you to read the article written by Colin Griffin from the Sport Surgery Clinic where calf strength and foot-ankle plyometric exercises are well described : https://www.sportsmith.co/articles/training-lower-limb-for-performance-and-reduce-injury-risk/.

VIDEO 6 : Foot-ankle rebound jumps on everted or inverted inclined board

4 How can practitioners (coach, S&C, physio) integrate this information within their own program?

The years that have passed have allowed me to have discussions or create collaborations with physiotherapists, S&C coaches or athletes from different sports. These discussions made it possible to create collaborations or give ideas for implementing foot strengthening in their athletic development or rehabilitation program. What I liked about every discussion was the fact that we started with the best option to strengthen their foot (everything I presented above) until using the least ‘worst’ option in their sporting context. Here are some examples of how we drive the “perfect/best” into the “least worst”:

Example n°1 with a physiotherapist from the French Olympic Youth Nordic Combined Team who wanted me to create a foot strengthening program for his athletes during a general athletic development of 2 months in off-season. The prerequisites were implementation of two sessions per week for a duration not exceeding 25 minutes. Considering this timeline, their sport necessity (be strong in the shoes before jump skiing) and their athletes’ perception (DOMS under the medial arch at the end of the cross-country skiing race) we choose to implement the “foot-bridge” exercise for midfoot region as well as maximal forefoot isometric contractions in a squat position (jump ski’ position).

Example n°2 with an international heptathlete athlete who wanted to have a warm-up dedicated to her foot muscles before sprinting races as she struggled with foot pain for years at max speed. The context was that the warm-up has to be done in the track outside a gym setting without any materials (squat bar, kettlebell). For this athlete I have to forget my principle of the importance of “body-over-loading” and using NMES on the track during different voluntary contractions (isometric, plyometrics) was the least worst option to maximize activation and warm-up of her foot muscles.

Example n°3 with a S&C coach in charge of the athletic development of two athletes from the French Olympic Bobsleigh Women’s Team. This collaboration is very interesting as the bobsleigh is the flagship sport of acceleration where transmitting a large amount of force efficiently on the ice play a major role in the final performance. The periodization of the athletic development during the year is characterized with 2 blocks of intensive foot strengthening during 3 weeks in addition to a “remind” session with one exercise every week. With the possibility to be in a gym-based setting, the block of intensive foot strengthening was created using all the previous exercises setting (forefoot, midfoot, 1st ray and foot-ankle coupled). The weekly session of foot strengthening was usually performed at home or in a hotel for example during the Olympics at Beijing. Therefore, the least worst option in this context was to perform isometric hallux contraction against a wall, doing the “foot bridge” exercise between 2 books or using NMES program.

In this last video you can see exercise streams of the different option that we choose with the staff for integrating foot strengthening in their own program.

VIDEO 7 : Integration of foot strengthening exercises in high-level structures/athletes

Conclusion :

I hope that this article will drive home the message that rehabilitation or S&C training might “under-load” the foot as it is capable of dealing with huge forces. Also, even this « stronger approach » with high-loads in the gym are no where near what are faced while running even at moderate to fast speeds. If we go even further it is important to remember that forces in the real world impact the foot structure in 3D and not just vertically or horizontally complexifying our exercise’ prescription. So Leonardo Da Vinci was right : "The human foot is a masterpiece of engineering and a work of art".

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