Expanded Gait Assessment and Evaluation and Validation of Minimalist Footwear

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Abstract

Assessment of gait has been used for many years to help a physician evaluate and treat a gait dysfunction in a patient and therefore help restore health and function; it is an invaluable tool. The typical gait analysis that has been described by previous authors and books has been expanded by this author. The new testing procedures in this paper will describe how to identify previously missed imbalances and validate the case for the use of minimalist type footwear and the rapid growth of the barefoot running movement of present day.

Key Indexing Terms
minimalist shoes, shod running, gait, barefoot, manual muscle testing (MMT), ligament interlink, kinesthetic sense, foot orthotics,

Introduction

Evaluation of gait is perhaps one of the most valuable tools a physician can learn. An imbalance or dysfunction in gait can ultimately result in the return of health problems. It is often a reason for the reoccurrence of neurological dysfunctions within the structural system itself or elsewhere throughout the body due to the relationship between the nervous system and the sensory feedback provided by the feet, known as kinesthetic sense.[1] Patients can literally “walk themselves back into a problem” if a gait imbalance is left untreated or if they perform some action to disrupt the gait. Often this occurs from the use of orthotic devices that were fitted to a dysfunctional foot and commonly from improper footwear.

Most often foot orthotic devices, as well as heel lifts, are prescribed to a patient at a time when there is some imbalance. This imbalance is typically in the foot, but may also occur separately or concurrently in a knee, hip, lower back, or other structural area. Due to the gait mechanism, even an upper limb imbalance can, and often will, result in a lower limb imbalance. Therefore, the entire gait as well as musculoskeletal system must be evaluated prior to a fitting or casting of any supportive device to ensure that the device supports

normal gait function and balance. If not, the device will only support the dysfunction. Although this support system may reduce or even eliminate pain, compensatory patterns will soon arise as the patient adapts to the uncorrected but supported injury/imbalance. This will eventually result in a new problem arising, which may or may not be near the initial complaint site.

Recently there has been a massive paradigm shift and movement towards minimalism in the running community as well as several footwear companies. This "back to basics" approach cites how humans were never meant to wear the common walking, running, and dress shoes which flood the market today. The term "shod" refers to some level of modern footwear that is typically characterized by a soft midsole, elevated heel, and potentially some form of motion control support device built into the shoe. The footwear industry often makes claims that one will run faster, jump higher, become stronger, or exercise muscles not otherwise used with competitor's shoes or while barefoot, yet there has never been any research to validate such claims. More interestingly are the claims of injury prevention, none of which can be substantiated through any scientific study.

The majority of the investigation into barefoot running and minimalist footwear focuses on the fact that experienced, habitually barefoot runners will avoid landing on their heel. The natural motion during barefoot running is to land with a midfoot, or even a somewhat forefoot, strike. A heel strike results in a significant stress to the body, whereas a midfoot or forefoot strike does not. The majority of running shoes have been developed to promote the heel strike, and therefore an unnatural running and gait cycle.[2] A built-up heel on a walking or dress shoe also results in a similar problem, though the force of impact generated via running is significantly more than walking. A thick heel on footwear will result in increased dorsiflexion while running, adding more stress to the body.[3]

A new term known as "drop" is being used to note the difference, in millimeters, between the heel and the forefoot. "Zero-drop" is the term for absolutely no change from heel to forefoot, as in barefoot. Currently the consensus is a drop of 4mm or less is considered "minimalist", though there is no standard criteria which must be met, and a thick supportive shoe with a 4mm drop may not be minimalist. Often conventional shoes have drops of 12mm or more, and as one may expect, the common "high-top" shoes and women's high heels have drops which often are more easily measured in inches. Increased heel height has been associated with increased EMG activity in both the vastus medialis and vastus lateralis.[4]

Most footwear contains supportive devices and excessive cushioning which can and often will disrupt gait.[5] Motion control stabilization devices are often added to the medial midsole of shoes to prevent overpronation. Though ultimately they can prevent pronation entirely, which results in gait disturbances and joint dysfunction as normal foot pronation is necessary to help absorb shock upon impact. Added cushions and pads, often in the heel of the shoe, also disrupt gait as well as nervous system function due to the resultant loss of the kinesthetic sense of the foot. Ultimately, the further away the foot is off the ground the more kinesthetic sense is lost which leads to more nervous system

impairment. This impaired foot position has been linked to increased falls in aging adults.[6]

Discussion

During normal gait, there is a continuous pattern of facilitation and inhibition. The physician can easily determine a normal or abnormal gait pattern using manual muscle testing (MMT). If a patient is placed in a gait position in which the right lower limb is flexed forward, with weight slightly shifted to that forward foot as if taking a normal step, then during a normal neuromuscular state, the right lower limb flexors as well as the left upper limb flexors will be facilitated. Likewise, in the same gait pattern, the left lower limb flexors and the right upper limb flexors should be inhibited. The exact opposite will hold true if the gait pattern is then changed to a left foot leading step.[7]

The physician can then clinically evaluate the function of the flexors and extensors of the patient during the gait cycle in order to determine if the gait is normal or not. For example, if the patient steps forward initiating a left forward gait, the physician would expect a right upper limb extensor, such as the latissimus dorsi to be inhibited (photo 1). A left upper limb flexor, such as the long head of the biceps or middle deltoid, (although an abductor, it functions as a flexor and is easy to see in the photo), would also be inhibited. The same muscles on the opposite side should be facilitated at this time. If the patient then switches to a right forward gait, the physician would expect the right deltoid to be inhibited (photo 2) as well as the left latissimus dorsi. Again, the opposite would hold true in each case for the muscles that should be facilitated.

photo 1

photo 2

An abnormal gait is defined as one in which the muscles are facilitated or inhibited at the wrong time. For example, if during the left forward gait the patient demonstrates a facilitation of the right latissimus dorsi or an inhibition of the right middle deltoid, then there is some gait disturbance.

The physician must make sure that the muscles being tested are functioning correctly before any gait testing is performed. Any inhibited muscles must be corrected first during the normal treatment and facilitated muscles must be tested for normal autogenic inhibition to make sure they are not over-facilitated. Otherwise, the physician may be testing muscles that are already functioning improperly.

The above testing procedures are examples of how physicians who employ MMT have evaluated gait for many years. However, this author has discovered that with new additional testing, as described next, the physician will uncover many previously hidden gait disturbances. The additional gait testing also supports the recent belief that barefoot and minimalist type footwear is not harmful to the body, yet non-minimalist footwear often is as it disrupts proper gait mechanics.

First, one must realize, the original gait test is more of an evaluation to determine the function of upper leg (not limb) and upper arm (not limb) flexors and extensors relationship to one another as they normally inhibit and facilitate one another through a gait cycle. However, it does not evaluate the function of the lower leg muscles responsible for plantar flexion (i.e., gastrocnemius, soleus and posterior tibialis) and those responsible for dorsiflexion (i.e., tibialis anterior and fibularis muscles) in their relationship to the lower arm and wrist flexor (i.e., wrist flexors and pronator muscles) and lower arm and wrist extensor (i.e., wrist extensors and supinator) muscles.

Using the previous example, if the patient steps forward initiating a left forward gait, the physician would expect a right lower arm extensor, such as the wrist extensor group, to be inhibited (photo 3). A left lower arm flexor, such as the wrist flexor group, would also be inhibited. The same corresponding muscles on the opposite side should be facilitated at this time. If the patient then switches to a right forward gait, the physician would expect the right wrist flexor group to be inhibited (photo 4), as well as the left wrist extensor group. Again, the opposite would hold true in each case for the muscles that should be facilitated or inhibited. Additionally, the muscles which are expected to become conditionally inhibited during the gait cycle should also turn on with autogenetic facilitation, (spreading the muscle spindle cell strengthens the muscle). For example, in the left forward gait, the physician should verify that the right wrist extensor normally strengthens with spindle cell activation.

Often the physician will discover that the upper arm muscles described earlier (in this example, middle deltoids and latissimus) will function normally in the gait pattern, but not the lower arm/wrist muscles (wrist flexors and extensors), when there is a subtle gait disturbance. This more specific testing is successful due to the interaction of joints during the gait cycle, referred to as ligament interlink, [8] but this application is entirely new.

photo 3

photo 4

A further expansion of the gait test is to check diaphragmatic function, since the fascia of the psoas muscles connect with the diaphragm and thus creates a strong relationship between breathing and gait. With the patient in either gait position, the physician should instruct the patient to inhale as deeply as possible and hold the breath. This should not disrupt the gait in any manner. If the physician is testing for the inhibition of the right latissimus dorsi and right wrist extensor group (left forward gait position), then the breath in should result in those muscles remaining inhibited. If they become facilitated, there is an imbalance that needs to be corrected, most likely in the diaphragm and previously discussed by this author.[9] Likewise, in this example, the right middle deltoid and the right wrist flexors should remain facilitated (and not over-facilitated). Next, the physician should ask the patient to exhale as much as possible and then hold the breath out as the muscles are tested again in the same manner. As with inspiration, there should be no change in any muscles in a normally functioning diaphragm-gait pattern.

If the gait is abnormal when the patient is barefoot, then the physician must investigate the source of the gait dysfunction. The source of the problem can be anywhere in the body. Once the patient is displaying a normal gait while barefoot, any orthotic device and/or inserts should be tested. Most often the physician will realize that the orthotic will disrupt the normal gait, especially in this new expanded procedure, as the orthotic was originally made for a dysfunctional foot/gait which is now being discovered.

Finally, and perhaps most importantly, any and all footwear the patient commonly wears should be thoroughly evaluated exactly as described above. The tests should be the same as performed previously when the patient was barefoot. First, the physician should test the upper arm/shoulder girdle muscles, followed by the muscles of the lower arm/wrist. Also, the test for the diaphragm should be performed again with full inhalation and exhalation. A failure of any test now will point to a problem with the patient's footwear.

Procedure

The physician may use other upper arm and lower arm muscles for testing as an alternative to the ones described here, but for the purposes and consistency of this procedure, the following muscles will be used: latissimus dorsi, middle deltoid, wrist extensors, and wrist flexors. Before the gait test is performed, the physician should verify that these four muscles are normal facilitated and can be inhibited by autogenic inhibition (shortening of the spindle cell = the muscle temporarily shows weakening).

1. While the patient is barefoot, perform the gait test as follows:
    a. In a left forward gait position, the right latissimus dorsi and the right wrist extensor group should be inhibited (weak) and the right middle deltoid and the right wrist flexor group should remain facilitated (strong). Check the right wrist extensor for normal facilitation.
    b. In a right forward gait position, the right middle deltoid and the right wrist flexor group should be inhibited (weak) and the right latissimus dorsi and the right wrist extensor group should remain facilitated (strong). Check the right wrist flexor for normal facilitation.
        i. If MMT of any of the above results in any variation, the patient has failed the test and the physician must correct the imbalance
        ii. If autogenetic facilitation does not strengthen a normally gait-inhibited muscle, such as the right wrist extensor in the left gait position, there is some gait disturbance that must be corrected
    c. Test full breath inspiration and expiration, testing for any gait disturbance caused by a diaphragm imbalance
        i. Correct any diaphragm (or psoas) imbalance found before continuing

2. Once the gait is determined to be normal (or corrected) while the patient is barefoot, the physician should perform the exact same tests as above (1a, 1b, and 1c) in the following manner:
    a. Standing in any orthotic, whether custom made or “drug store” type. These should be removed from the shoe for testing
        i. If the orthotic disrupts the gait in any way, they should be discontinued. If they do not, set aside
    b. Standing in the footwear
        i. If the footwear disrupts the gait in any way, the patient should be instructed to seek out a more minimalist-type footwear or sandal
    c. Standing in the orthotic placed in the footwear (only if both 2a and 2b did not cause a gait disturbance)
        i. Typically the patient would have failed the gait test individually either with the orthotics or the footwear, but they should also be tested together to be certain

3. Regardless of the outcome, the patient should be advised to walk barefoot as much as possible, especially while at home.

CONCLUSION

A thorough gait assessment is a vital part of each and every appointment. Patients are literally walking themselves back into distress due to uncorrected muscle imbalances, unnecessary orthotic devices, and especially improper footwear. Although individuality is part of the essence of MMT, the physician will soon realize that there are shoes that will almost always pass the gait test and shoes that will always fail. Women's high heels, especially over two inches, never pass the gait test, particularly using the new expanded wrist flexor/extensor test. Flat sandals, typically under one-half inch high across the entire sandal, rarely fail. Footwear with anti-pronation devices and stabilization added to the midfoot typically fail, as do shoes with excess cushioning.

Using MMT the physician can determine what shoes will not harm the patient during their daily activities and during exercise. Notice that the word "benefit" was not used, as footwear is not meant for this reason. It should only protect the feet from damage that may be result within a particular environment. It is advised that the physician ask the patient to bring in various pairs of regularly worn footwear, though caution should be made when making this offer to some women (bags of high heels may soon flood the office)! Common problems seen are patients wearing the wrong size shoe (one to two sizes too small is very common), too high of a heel (due to too much drop), too much support, or entirely too far off the ground (such as with platform shoes).

The feet are loaded with nerve endings that sense contact with the ground and those nerve endings communicate with the brain and affect the entire nervous system. Therefore, advising the patient to go barefoot as much as possible and directing them towards more minimalist type shoes will ultimately provide substantial health benefits, often beyond those that are only structural.

The following are some points to consider when advising your patients on footwear:

1. **Simple**: No "fancy shoes" especially ones that make claims to increase performance or work certain muscle groups
2. **Flat and Firm**: Keep them low to the ground – throughout the entire shoe – and especially the heel. A low to zero-drop shoe is always best
3. **Flexible**: Make sure the shoe can be flexed throughout the entire sole – especially the midsole where the arch of the foot sits – and the shoe should be rather firm, not too much cushion which alters proprioception
4. **Roomy and Wide**: Take the insoles out and have them step in them to make sure the foot fits well into the outline of the insole – the big toe should never go past the insole and ideally should be about 1/4"-1/2" behind the tip of the insole. Check the width too as most shoes are made too narrow for the foot. The toes need to splay properly during the gait cycle
5. **Level**: Make sure the shoes look somewhat level on a flat surface as defects do occur during manufacturing

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