Methods of Measuring Intrinsic Foot Muscle Strength: A Systemic Review

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Abstract
A concept of core stability recently extended to the arch of the foot where the support is provided by both extrinsic (global movers) and intrinsic (local stabilizers) foot muscle. Intrinsic muscle act as stabilizers for Medial Longitudinal Arch (MLA) and weakness of these muscle associated with the height of the Navicular bone which is directly linked with the morphology of the foot and can cause varieties of foot disorders and deformity. The purpose of this analysis is to offer a systemic review of the research directed toward the evaluation of different method to measure intrinsic foot muscle strength in terms of their reliability and validity. The search will be performed using PRISMA Guidelines, relevant keywords will be used for the search through the electronic database PubMed, PEDro, MEDLINE, SCOPUS, CINAHL and Cochrane Reviews till November 2019 to locate the scientific research on method of Intrinsic foot strength Measurement. Downs and Black Checklist is used to assess the methodological quality of intervention studies. The abstract of the located articles will be read to select the appropriate article and full text was evaluated of the relevant research. There is no broadly recognized technique of determining intrinsic foot muscle strength. Some of the design use Hand-held dynamometry which limits toe curling, which is hypothesized to enhance the activity of intrinsic toe flexor muscles. Also, most methods do not take position of ankle in consideration as it directly influences the action of extrinsic muscle and help to isolate the plantar intrinsic muscle. Measurement of Planter intrinsic muscle strength in isolation still possess a major challenge among clinicians. Most Hand-held dynamometry appears to be a promising method if the position of ankle should be taken care and some of the clinical method is used to isolate the intrinsic muscle.

Keywords: Foot, Muscle, Toes, Muscle strength, Dynamometer

Introduction
Human feet are made up of 29 muscles which can be divided into two distinct groups. There are 10 extrinsic muscle which originate outside the foot and 19 intrinsic muscles which originate and act in the foot itself. [1] Over the year it is believed that the role of intrinsic muscles are gradually diminishing since the use of footwear and over the year these muscle become rudimentary to the human foot which is partially correct also for the dorsal intrinsic muscle [2].
A foot core system described by McKeon PO et.al [3] help us to understand that these four-layer plantar intrinsic muscle act as local stabilizers and help in medial arch support with extrinsic muscle which act as the global movers. [4,5]. Weakness of intrinsic muscle may cause problem directly related to the foot morphology and pain like claw toes, pes planes, pronated foot, heal pain, planter fasciitis etc. [2, 6-14]. The overuse and weakness of these intrinsic muscle are responsible for the development of foot disorders and there is a need for a reliable and valid instrument to measure the weakness of these muscle. There are distinct methods available to meet this demand [12-24], but till now there is not a single fixed method or instrumentation available which is regarded as most appropriate way to measure the foot intrinsic muscle. Therefore, the aim of this review was to evaluate the different instrument who claimed to measure intrinsic foot muscle strength.
Material and Methods

Relevant keywords will be used for the search through the electronic database PubMed, PEDro, Cochrane Library & Google Scholar from Jan 2011 till December 2019. An open source reference management software Zotero was used to manage bibliographic data and related research materials. Keywords used are related to the intrinsic muscle and tools to measure their strength are listed in Table 1.

Table 1 Keywords used for search in electronic database

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<table>
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<tbody>
<tr>
<td>1</td>
<td>Intrinsic foot muscle</td>
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<tr>
<td>2</td>
<td>Intrinsic foot muscle measurement</td>
</tr>
<tr>
<td>3</td>
<td>Intrinsic foot muscle strength</td>
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<tr>
<td>4</td>
<td>Toe Dynamometer</td>
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<tr>
<td>5</td>
<td>Hand held dynamometer</td>
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<tr>
<td>6</td>
<td>Fixed Dynamometer</td>
</tr>
<tr>
<td>7</td>
<td>Planter Plates</td>
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</tbody>
</table>

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Diagram [25] is used to report this systemic review.

Inclusion Criteria

- Study associated with the role of intrinsic foot muscles
- Study allied to the anatomy of intrinsic foot muscles
- Study relating the strength measurement of intrinsic foot/toe muscles
- Study related to Toe Dynamometry
- Study related to the clinical investigation of foot intrinsic muscle
- Publication in peer-reviewed journals
- Publication is in between Jan 1999-Dec 2019
- Full-text English language articles

Exclusion Criteria

- Grey Literature
- Predatory Journals
- Unpublished articles
- Personal Blogs
- Press column

Further the methodological quality of intervention studies was assessed using the Downs and Black checklist [26]. The abstract of the located articles will be read to select the appropriate article and full text was evaluated of the relevant research.

General procedure:

The related research material in managed in the Zotero and the duplicate research article was cancelling out and the PRISMA Flow Diagram is created (Figure 1) by using the online URL http://prisma.thetacollaborative.ca

Downs and Black checklist is used to measure the methodological quality of 123 articles are assessed by and based on its criteria only 63 articles were eligible for the final list with the average score of 22 which is good in terms of the grading of the scale. The scoring of the scale was done by the reviewer and the external reviewer both and the discrepancies were sorted out in the one to one meeting.
Detection Method:
The full text of these 63 Research articles were reviewed for and different method and tools used for measurement of planter intrinsic muscle were listed.

Results and Discussion
There are variety of Instrument and techniques, clinical test and laboratory test which are directly used to for the measurement of the muscular force of planter intrinsic muscle [11, 14, 18, 19, 27, 28]. One thing is very certain in all the literature that all the direct method measure only the toe flexor muscle force and other action of the intrinsic muscle like abduction or extension is seldom measured in the literature. Since toe flexion use both intrinsic muscle and extrinsic muscle it is very difficult to tell whether these techniques are measuring the intrinsic muscle or extrinsic muscle as no instrument and laboratory testing isolate the intrinsic muscle and these muscle also work in group so it is very difficult to isolate the action of these muscle with the help of Direct measure. The major instrumentation and the special test which are mainly used in measuring the strength of Planter intrinsic muscle are listed in the Table 2.

Table 2 Direct instrumentation and testing for the strength of Planter intrinsic muscle

<table>
<thead>
<tr>
<th>Instrumentation</th>
<th>Special test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toe Dynamometry</td>
<td>Paper Grip Test</td>
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<tr>
<td>Pressure Plate</td>
<td>Intrinsic positive Test</td>
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Toe Dynamometry
There are 12 research articles in which the investigation of intrinsic muscle strength was measured by the Dynamometer in most of the research the hand held Dynamometer is used and some of the instrument are tailor made for the purpose of research these instrument either use straight away or they are a part of one architecture which is designed in terms of measuring the planter muscles the summery of these articles are mentioned in Table 3. One more significant consideration while determining intrinsic muscle strength is the position of the ankle joint. Spink and co-workers [28] in their study hypothesised about it, according to them if we can control the ankle passively and maintain it in plantarflexion while measuring the planter intrinsic muscle it will put the external muscle of the foot which are generally prime movers in shortened position and they will generate minimal force in this position. None of the instrument put the ankle plantarflexion while recording the toe flexor strength.
Table 3 Various Toe Dynamometer claim to use for planter muscle strength

<table>
<thead>
<tr>
<th>Research Paper</th>
<th>Instrument</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daisuke U et.al (2012) [29]</td>
<td>Dynamometer (T.K.K.3361)</td>
<td>This dynamometer promotes the toe flexion but also it allows the curling of the toes which is action of the extrinsic muscle. Pushing mechanism also promote the flexion at the IP Joint</td>
</tr>
<tr>
<td>Yasuhiro Y et.al (2018) [37]</td>
<td>Custom-made dynamometer</td>
<td>Doming Action of the feet with hand held dynamometer certainly activates some of the extrinsic muscle</td>
</tr>
<tr>
<td>Sarah R et.al (2017) [31]</td>
<td>The Brannock device with handheld Dynamometer</td>
<td>All these instruments certainly cause the flexion of the IP Joint which enhance activity in the extrinsic muscle.</td>
</tr>
<tr>
<td>Spinke M et.al (2010) [28]</td>
<td>Handheld dynamometer (Rowley et al)</td>
<td>Among all the instrument Hand held Dynameter is close to accuracy while measuring the intrinsic muscle strength as it promote the flexion at MTP while IP remains in Extention</td>
</tr>
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</table>

Paper grip test

The Paper Grip Test has two variant PGT 1 and PGT 2 used to measure the intrinsic muscle strength in Great toe (PGT 1) and combined lesser toes (PGT 2) this test is performed by the help of piece of paper just like the visiting card. the PGT1 is capable of selectively demonstrating intrinsic foot muscle weakness and it is having outstanding interrater (ICC 0.87) [38] and reasonable interrater reliability (ICC 0.56) [39] while measuring patients with leprosy and healthy individuals. Moreover, as the participant demonstrate these test they tend to curl their toe and this action is subjected to the extrinsic muscle of foot, the EMG experiment shows that the extrinsic muscles were also activated during the PGT [38] Therefore this test validity in questionable as it probable assess both planter intrinsic and Foot extrinsic muscle strength.

Pressure Sensors

Plantar pressure sensors can calculate the strength in terms of force beneath the toes. These instrument are of two types; it can be either use as in shoe design or by Force plate as Platform System. The test-retest reliability of these pressure plates is exceptional in both devices to measure both great toe and lesser toe strength but as seen in Paper grip test its validity of testing the intrinsic muscle strength is still questionable as it does not isolate the intrinsic muscle and can determine the strength of both intrinsic and extrinsic foot muscle.

The Intrinsic Positive Test

This test is the qualitative measure used to determine the function of the planter intrinsic muscle of the 2,3,4,5 Toes [40]. The test involves the participant extending the great toe while simultaneously attempting to flex the lesser toes at the MTP joint and extend the interphalangeal joints. Also the validity and reliability of the intrinsic positive test has not been investigated thoroughly and quantification of this test cannot be done.
Conclusions

Till now there is not a single method or instrumentation is available which can measure the planter intrinsic muscle strength accurately. All the methods which are available just measure overall toe flexor strength as none of the instrumentation and special test able to measure the intrinsic muscle in isolation. Method such as Paper grip test and planter pressure plates are good on reliability but their validity is in question as both of them promote the toe curling which is not a correct movement as it involves extrinsic foot muscle. Hand held dynameter promote the IP Extension with MTP Flexion it is one of the suitable instrument with some limitation furthermore none of the method till now put suitable emphasis on the position of the ankle which is again is very important in term of reducing the impact of extrinsic muscle on the foot. Designing the instrument to measure the planter intrinsic muscle still challenge for the clinicians as we must test the strength of these muscle in isolation while designing any instrument make sure it can use some clinical method like EMG to isolate the intrinsic muscle and put more emphasis on the positioning of the ankle.

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References


