Lack of Standardization of Ankle Instability Measurement and Orthopedic Care

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

As an individual with chronic ankle instability (CAI) in both ankles, I have accumulated well over 20 plus ankle injuries throughout my young athletic career. With each occurring ankle sprain, the regimen was the same— ice, elevate, compress, anti-inflammatory drugs, appointment with an ankle orthopedic specialist, x-ray and/or MRI, protective ankle boot and crutches, and then physical therapy. Despite efforts, progression of my ankle instability became rampant once I entered high school, and all of a sudden in college, I found myself rolling my ankle once a month or so. This progression was so quick, painful, hindering, unrelenting, yet sneaky. Reflecting back, this rapid trend and it never being appropriately tracked or measured is what makes ankle instability sneaky.

The overload and accumulation of this ankle trauma over 14 years in high-impact sports caused a complete tear of my anterior talofibular ligament (ATFL), the most prominent ligament in one's ankle, that completely fractured and segmented the distal, or most bottom portion, of my fibula. Additionally, I had multiple bone spurs, or abnormal growths of bone in response to stress and trauma, extensive damage to my extensor retinaculum, a sheet of ligaments that overlays the tendons at the front of one's ankle, and other substantial and extraneous ligamentous damage. In summary, I had to get an extensive arthroscopic ankle debridement and reconstruction surgery. This surgery, however, was a long time coming and very delayed until experiencing extremely severe and debilitating pain. My ankle was not deemed "unstable enough" for surgery. Yet, right up until this option was approved for me, I had two ankle sprains over the course of two months—both of which were caused simply by stepping downstairs, not by completing a multi-series tumbling pass or by catching a girl from a dangerous stunt fall.

As seen through my experience, ankle instability results from recurrent ankle sprains and trauma to the ankle. Severe pain and reduction in the capacity of daily activities, such as walking, running, or jumping, can result from ankle instability, rendering individuals in a vulnerable and frustrating state. With each ankle injury, the ankle ligaments become weaker, the ankle joint becomes more inflamed, and the likelihood of ankle reinjury skyrockets (Aicale & Maffulli, 2020). Like me, 73% of the two million acute ankle injuries per year are due to the ATFL, and 70% of these individuals, with higher incidence among athletes, will develop CAI (Herzog et al., 2019). Diagnostic accuracy of ankle instability is critical to effective patient treatment, positive clinical outcomes, and prevention of its advancement as its measurement guides clinical decisions. Additionally, most ankle treatment options are purely elective and physician guided, highlighting the importance of accurate diagnosis and appropriate physician suggested treatment. Conservative treatment, such as bracing, is initially opted for when treating only acute ankle instability and more rigorous treatments, such as surgery, are reserved for extremely long-term and advanced ankle instability. If ankle instability is untreated or not properly treated, frequency of reinjury increases, leading to an increased likelihood of CAI and later, development of post-traumatic osteoarthritis (PTOA) in the ankle (Herzog et al., 2019). Up to 40% of ankle sprains are misdiagnosed or inadequately treated as current ankle instability measures are completely subjective (Cavazos & Harkless, 2021), and 78% of individuals with CAI are likely to develop PTOA (Camacho et al., 2019).

Current subjectivity and inconsistency within ankle orthopedic measurement and care has a multifaceted impact upon health providers, patients, and researchers. This topic is deeply rooted in the lack of standards and inability to measure ankle instability objectively. It is a problem that has been well established in literature and can be observed in medical practice. I investigated

actors touched by this topic utilizing Actor-Network Theory (ANT) through sources such as online journal articles and media websites. These research methods led to the unveiling of actor relationships and constructs that further support this claim beyond its immediate impact. I conclude that the climate surrounding the lack of standardization within ankle instability measurement and the inability to do so in an objective way self-perpetuates a cycle that hinders advancement in this field, equal access to care, adequate staffing to meet demand, and overall better care for the patient.

Methods

I utilized literature analysis methods guided by ANT fundamentals to analyze the climate surrounding ankle instability orthopedic care that enables a complex, perpetuating system whose impacts have been deeply rooted into the medical ecosystem. Actor-Network Theory (ANT) framework explores "both human and non-human elements equally as actors within a network" (Cressman, 2018, p.3) and was utilized with the intent to uncover the current deficits in ankle orthopedic care. Researchers have argued the importance to evaluate technology in health services utilizing ANT (Cresswell et al., 2010). This theory can be simplified as a fluid web of nodes with each node being human or non-human. Every node has its own inherent, enabling and constricting characteristics, its socially constructed role, and impact on other nodes (Latour, 2005). The actors investigated are standards, ankle instability measures, orthopedic physicians, orthopedic professional trainees, orthopedic associations, researchers, and patients. I utilized literature analysis of over 20 orthopedic academic journal articles and orthopedic association websites to contextualize and analyze each of these nodes within this network.

A few limitations exist to this research. Access to such resources proved to be challenging as many journal articles, medical textbooks, and information regarding said actors

were behind paywalls or only accessible through membership. As there is limited documented information available, some assumptions about these actors were made based on common knowledge of the workings of the medical field through experience and my technical advisor.

Analysis Overview

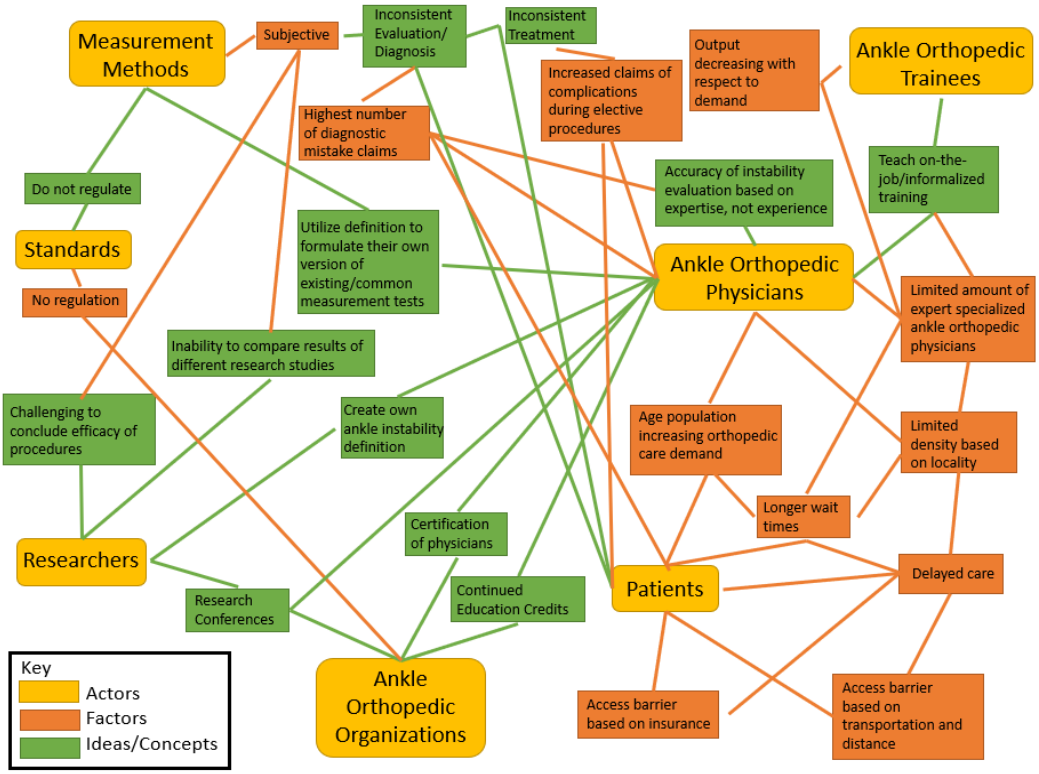

Figure 1: Ankle Instability Measurement and Care Actor-Network Diagram

Created by Haley Frye

Literature Review and Analysis of Actors

Each of these actors are very complex and the overall network interactions are cyclical similar to the chicken or the egg paradox. An Actor-Network overview is provided above (Figure 1). However, to aid in understanding and analysis, context surrounding the background of each actor will be given through literature review followed by the analysis and conclusions.

Discussion will begin with the main problem at the heart of this issue: the lack of standards in ankle orthopedic care.

Standards

The lack of standardization regarding orthopedic care is evident in the literature and medical practice. Standards in this context pertain to regulated requirements set by a governing body that guide medical decisions and treatments. Standardization is the process by which these standards are consistently enforced or accepted, implemented and used, and taught. For example, a medical standard provided by a medical authority could outline the process by which a physician measures and grades ankle instability and outlines treatment decisions based on the grade of instability. This standard would be followed and implemented by all certified orthopedic physicians, resulting in absolute consistency across all physicians.

However, simply stated: there are no standards and there is no standardization within ankle orthopedic care and instability measurement. Many actors later discussed perpetuate this problem; though, the definition of ankle instability is the egg of this chicken paradox. Researchers have cited the difficulty in clearly defining ankle instability, as no universally accepted definition or gold standard measure currently exists to quantify it (Donahue et al., 2011, p. 1140; Simon et al., 2014). Although, some standards exist surrounding ankle orthopedic care as orthopedic medical professionals must be state licensed and are mostly required by employers to be board certified by their specialty or subspecialty (Licensing and Board Certification, 2019). Despite this, it is unclear how detailed this standardized exam tests and expects medical professionals to have knowledge regarding ankle instability measurement and care.

Ankle Instability Measures

Due to the lack of standardized standards in ankle instability measurement, medical professionals acting as and collaborating with medical researchers have been forced to self-innovate ways to measure and gauge ankle instability. Circling back to the egg, since no standardized definition or requirements characterize ankle instability, researchers and medical professionals have defined to themselves subjectively what is important when measuring ankle instability (Donahue et al., 2011, p. 1140). This has given rise to differing categories of techniques to characterize ankle instability such as stress tests, patient-reported questionnaires, and performance-based testing to name a few. Each of these methods have their own varieties and subsets like a root of a tree expanding into more roots that each have their own roots. This expansion is due to the absence of unified definitions and methods accompanied with physician experimentation and preference. For simplicity, only stress tests and patient-reported questionnaires will be discussed and included as actors in this network. Manual stress tests are most commonly utilized in-clinic, stress radiographs are rarely used, and questionnaires are occasionally utilized according to my advisor, but all are utilized in research.

a) Stress Tests

Stress testing of the ankle is a means to which a physician or entity manipulates a patient's ankle by applying directional forces, stressing particular ligaments within the ankle. A healthy, strong, stable ankle will not have laxity or "give" in its ligaments upon this applied force. An unstable ankle will have movement or "give" in its ligaments upon this applied force, indicating ligament damage and weakness in stability and strength. Two techniques exist in this method of measurement: manual stress tests and stress radiographs.

a. Manual Stress Tests

Manual stress tests are dynamically and manually conducted by a specialized orthopedic physician on the patient's ankle to test the laxity of specific ligaments within the ankle. Physicians, based on their experience and expertise, *subjectively* gauge the resultant movement of the ankle during these tests and correlate it to the instability of the particular ligament and ankle overall (Wenning et al, 2021). The degree of abnormality is estimated on a scale of pluses or a 0-to-4 scale with no specific guidelines or easily measurable demarcations. Very few devices have been created to quantify the amount of movement of the ankle during these exams; although, these devices have been noted by researchers to be designed for research only and are impractical in-clinic tools (Wenning et al., 2021). Additionally, no standardized practice entails as to how the tests should be conducted exactly. Due to this, countless renditions of varying similarity exist.

Great subjectivity exists in manual stress tests, leading to inconsistent diagnosis from provider to provider, or low inter-rater reliability, and inconsistent diagnosis based on replicability by the same provider, or low intra-rater reliability. This claim is heavily supported in literature. For example, a meta-analysis of 16 different studies of physical examination tests for the assessment of ankle instability concluded inconsistent results among reliability and validity of such tests, but showed that none of the tests had robust reliability and validity scores (Beynon et al., 2022). This emphasizes that inter- and intra-rater reliability of these tests is low, leading to poor validity based on inconsistent diagnosis.

To emphasize greater subjectivity and inconsistency in diagnosis, the expertise of the physician directly impacts the quality of the tests and judgement

of instability. In fact, a study noted when examining test sensitivity, judgements for physical examinations varied from person to person and noted low sensitivity in less experienced hands (Li et al., 2020). In addition to this, Beynon et al.'s (2022) meta-analysis concluded that seven of the studies compared examiners of varying degrees of experience and found mixed results regarding if more or less experienced examiners yielded higher results. This shows that diagnostic accuracy is not necessarily based on physician experience, but based on expertise of the specific physician. Diagnostic insufficiencies and general diagnostic error can be linked to the latent error (Rodziewicz et al., 2022) within how these tests are not standardized among physicians and subjectively judged based on expertise.

Researchers have questioned the diagnostic accuracy of these manual stress tests and their ability to truly test what is expected (Croy et al., 2013). Many studies have attempted to validate the diagnostic accuracy of these exams and the inconsistency found among differing studies could be linked to latent errors previously discussed.

b. Stress Radiographs

An ankle stress radiograph is an x-ray of the ankle during static or constant mechanical stress, such as stresses alike to those exerted during manual stress tests. Using this methodology, the tilt angle and anterior translation of the ankle can be measured from the x-ray scans (Choi et al., 2021), being a quantitative measurement of ankle laxity.

Stress radiographs have numerous negative impacts upon patients and medical providers, inhibiting its adoption. To take the scan, a prolonged period of stress exertion must be maintained by a healthcare provider to take the x-ray. This sustained force and stress on the ankle joint causes pain and significant discomfort to the patient. It also leads to radiation exposure to all involved, the patient and the provider performing the radiograph. Devices to maintain the applied stress and eliminate the provider during the scan have been created and tested in studies. Yet, Aguiar et al. (2017) noted that it is difficult and may be painful to be performed in acute cases, it is not a validated method to apply stress force, rotation of the limbs may occur and alter the imaging, and the device can increase the stress strength of the patient. This results in patient harm and inaccurate or false x-ray images, and thus incorrect parameter measurement.

Despite this method utilizing quantitative measurements, faults within its methods reduce its validity and usability and therefore, have potential for adverse effects regarding patient care. Researchers concluded that replicability and consistency within scans among one patient is low and not acceptable (Choi et al., 2021), resulting in low intra-rater reliability similarly to manual stress tests. Choi et al. (2021) concluded that a reliable and accurate decision regarding patient ankle instability treatments should not be gathered from one ankle stress radiograph scan. Additionally, this type of scan is typically applied only to patients with severe instability in order to be able to quantify a notable difference, limiting its applicability and increasing the likelihood of unnecessary patient harm if conducted on a patient that does not have severe enough instability.

b) Self-Reported Questionnaires

Researchers aimed to include patient-perceived instability into ankle instability measurement utilizing patient-reported questionnaire, also known as patient-reported outcome measures. Over eleven different questionnaires emerged from researchers and the variety between them can be linked back to not having a universal definition and set criterion of ankle instability.

"While these questionnaires are widely used, it is unclear how accurately each measure predicts a participant's ankle stability or instability status" (Donahue et al., 2011, p. 1141). This conclusion can be attributed to the very nature of these exams as they allow for subjectivity and inconsistency in diagnosis based on patient reporting. Many barriers to completing patient-reported questionnaires successfully such as platform design, print literacy, health literacy, technology literacy, language proficiency, physical functioning, vision, cognitive functioning, and the relative time in-clinic to complete such surveys have been reported (Long et al., 2022). These barriers serve as challenges in completion, accuracy, and correctness of these surveys.

Orthopedic Physicians

Orthopedic attendings adopt their own practices as to measure ankle instability, and as stressed earlier, each of the above measurement methods are highly prone to subjectiveness. Depending on the physician seen, patients are likely to receive differing opinions regarding the degree of ankle instability, diagnosis, treatment, and outcomes. Clinicians may guide their patients conservatively or liberally based on their own opinions, impacted by their varying backgrounds, clinical experiences, and age. This subjectiveness directly impacts patient treatment, recovery, and future activity level, and is a reason to have significant concern.

As previously concluded, the level of expertise of the physician determines the diagnostic accuracy of ankle instability measurement and judgement. This narrows the pool of available physicians able to provide accurate care to patients. The future demand for musculoskeletal care has been estimated to heighten 20% from 2020 to 2030 due to increasing age population (Day et al., 2016). The existing population of ankle orthopedist, output of medical school orthopedic residency graduates, and foot and ankle fellows has not kept pace with this projected demand, especially among the wave of orthopedic physician retirement (Day et al., 2016; American Academy of Orthopaedic Surgeons, 2016; Chan et al., 2020). From the AAOS 2018 census, the density of orthopedic surgeons in the US is 9.25 per 100,000 population with the proportion of foot and ankle surgeons a fraction at 5.2% (American Academy of Orthopaedic Surgeons, 2019).

The lack in numbers and density coverage of expert and specialized ankle orthopedist creates an immense barrier to care for patients and equally harmful effect on physicians. Heightened and sustained demand for appointment availability for specialized orthopedic physicians creates longer wait times for care, delayed care, and quicker burnout of physicians (Travers, 2020). Nugent et al. (2020) have supported this claim in literature citing that 53.8% of foot and ankle physicians and 67.7% of sports medicine physicians have burnout. This condition is characterized by emotional exhaustion, depersonalization, and decreased sense of accomplishment due to stress (Lazarides et al., 2021). Serious ramifications of burnout exist including committing medical errors, strained patient-doctor relationships, depression, and thoughts of self-harm (Lazarides et al., 2021; Travers, 2020). In addition to this, increased likelihood of malpractice lawsuits inflates burnout rate (Sanders et al., 2021; Travers, 2020). Orthopedic surgery has been identified as a high-risk specialty to receive malpractice claims with the foot and ankle regions accounting for a surmountable number (Sanders et al., 2021).

Increased amount claims in orthopedic surgery are due to diagnostic mistakes, delay in diagnosis, and complications of an elective operation with the highest number of claims of the former (Sanders et al., 2021).

These diagnostic mistakes are due to the highly subjective ankle instability measurement methods that require expert physicians for proper and accurate diagnosis. In fact, most ankle surgeries are elective and are guided by physician recommendation to the patient. This further emphasizes the importance of diagnostic accuracy of ankle instability and physician recommended treatment. Sanders et al. (2021) found a substantial number of claims to stem from ankle surgeries, majority of which were elective.

Addressing the low density, "only 30 percent of rural hospitals are staffed with a full-time orthopedic surgeon, so patients often must travel long distances for care, prompting many to delay treatment, resulting in poorer outcomes and increased costs" (Carver College of Medicine, n.d.). Locality, access, and transportation to orthopedic physicians is low for individuals in rural areas, especially since small practices cannot support specialist. This creates a large barrier to care for these individuals, that results in delayed diagnosis and care. Sanders et al. (2021) found that many claims arise from delay in diagnosis.

The subjectivity within ankle instability measurement tests requires patients to seek out expert physicians, creating all of these unforeseen barriers and serious impacts to patients and providers alike. A large disruption in the standardization of orthopedic care is the lack of access to orthopedic care in particular areas and to particular social groups, and the resultant societal ramifications of this.

Orthopedic Trainees

Orthopedic trainees, including medical students, medical residents, and fellows, undergo unformalized training for specialized fields, such as ankle orthopedics, through on-the-job training by senior medical professionals. Lack of standardization within medical training further exacerbates the lack of standards when measuring ankle instability and determining care. Returning to the analogy of the expanding roots, preferential training of specific techniques by attending physicians to orthopedic trainees further diversifies and expands the gap of consistency within ankle medical practice. Being that these techniques and tests are subjectively evaluated, the quality and consistency of training of orthopedic trainees by senior professionals is very important. Complicating this further is the issue that expertise in judgement and diagnostic accuracy is not necessarily correlated with experience. This creates a large area of concern within training of young orthopedic trainees in ankle instability measurement and care due to the blind leading the blind in many training programs.

Orthopedic Associations and Organizations

Great potential exists for this actor to rectify standardization within orthopedics and ankle instability measurement. Orthopedic associations and organizations do serve to inform orthopedic physicians, enable research opportunities and research sharing, continued education, and certification. The American Board of Medical Specialties (ABMS) oversees all subspecialty boards such as the American Board of Orthopaedic Surgery (ABOS). ABOS "maintains the highest standards for education, practice, and conduct through examination, certification, and maintenance of certification" (American Board of Orthopaedic Surgery, n.d.). The ABOS board certifies orthopedic surgeons and physicians. However, in order to practice, orthopedist do not have to be board certified, but it is heavily recommended and required by some employers. ABOS also establishes educational standards for orthopedic residents by evaluating their

qualifications; however, it is based on the minimum educational requirements of the specialty. This actor does play a role in a form of ensuring competency of orthopedists, but the degree and detail to which it acts is minimal and does not provide enough standardization of standards among physicians.

Other professional associations such as the American Academy of Orthopaedic Surgeons (AAOS) and the American Orthopaedic Foot & Ankle Society (AOFAS) provide education opportunities for continued education through webinars, online learning, live and virtual courses, and research meetings (American Academy of Orthopaedic Surgeons, n.d.). These actors play a role in physician education and research; however, they do not regulate standards regarding ankle instability measurement.

Researchers

Given the subjective nature of these tests and the large variety to which these tests exist, equivalent comparison across research studies in order to evaluate surgical effectiveness is near impossible. In a retrospective analysis of post-surgery instability using subjective questionnaires Buerer et al. (2013) support this claim stating, “the disparity of the results obtained with the different scores shows the necessity to establish a common evaluation system in the literature to assess ankle instability and its treatment options” (pg. 11). In addition to this, the subjective character of mechanical stress tests allows integration of patient presentation and perception, reducing applicability in longitudinal and postoperative evaluation due to a potential systemic bias (Wenning et al., 2021). This same sentiment can be extended to all subjective measures on the basis of the inherent issue of subjectivity. In meta-analysis studies, researchers time and time again are unable to confidently draw mass-scale conclusions on the basis of incompatible, subjective measures. This conflicting situation does not allow comparable or productive research

in this field on instability and effectiveness of procedures, which is necessary to halt the perpetual inconsistencies and lack of standardization.

Patients

Harm to patients on multiple levels due to the lack of standardization within ankle instability measurement and care has been intertwined in previous discussions regarding other actors. As previously elaborated on, a large disruption in the standardization of orthopedic care is the lack of access to orthopedic care in particular areas and to particular social groups, and the resultant societal ramifications. Summarized impacts on patients clearly stated include: incorrect diagnosis and resultant treatment based on measurement subjectivity and inherent issues to completion of questionnaires, limited access to appointments based on heightened demand and physical location, and delayed care based on the demanding backup. Among these impacts, the ability for an individual to be wrongly diagnosed and/or to be suggested to undergo an elective procedure when not necessary alone is an indicator for egregious concern.

Another sizeable barrier to specialized ankle orthopedic care not yet discussed is the barrier based on socioeconomic status and insurance. Physicians prioritize patients based on severity of issue and, depending on the practice, may prioritize based on insurance payout. To support this, patients with Medicaid insurance had limited access to care in 32% of orthopedic practices (Labrum et al., 2017, as cited in Salazar et al., 2019) and had an average 36.2 miles 1-way distance traveled to orthopedic appointments (Salazar et al., 2019). Another study found that general orthopedic practices would accept an uninsured caller for an appointment 5.7 times higher than a Medicaid caller, but the same odds as a privately insured caller; however, uninsured patients had to bring a median of $350 to be seen (Medford-Davis et al., 2017). This can be paralleled with the amount received by insurances or the individual to the practice as

privately insured patient's payment was $236, Medicaid $128, and uninsured ranging from $250 to $400 (Medford-Davis et al., 2017).

Due to the specialization and expertise in ankle instability measurement and care, a patient must seek out expert physicians to receive effective care, thus streamlining patients to this small population, causing and/or stressing the issues listed previously.

Conclusion

The segmented and seemingly unconnected actors within the climate of the lack of standardization within ankle instability measurement are more closely connected and directly impacted by this problem than anyone might initially think; however, from this analysis, I conclude this problem is a self-perpetuating cycle that is influenced, created, and shared among all actors. All investigated actors must do their part to reform and reshape this climate, and this circles back around to research and innovation of the egg in the chicken paradox.

A vital actor is missing from this network and has been excluded from this discussion: engineers. In the actor investigation, the existence of two quantitative and objective research tools to measure ankle instability was presented; however, many shortcomings prevent acceptance as a gold standard way of measurement. Improvement or creation of these devices geared towards dual clinic-use and research-use is necessary to even start to address many of the issues presented in this paper. To overcome this grand challenge, change must start in the innovational space with medical professionals and engineers collaborating to create a dual use tool to objectively and quantitatively measure ankle instability during manual stress tests in a reproducible and consistent manner that can implemented into the gold standard. Following this, non-addressable issues can start to be addressable.

Future research between engineers and orthopedic physicians utilizing such tool would eliminate many limitations and drawbacks discussed in this paper over time. Immediately, however, research investigating ankle instability severity (i.e., stable, moderately stable, severely unstable) characterized by such measurement parameters would begin to formulate a more objective definition of ankle instability, addressing one of the most prominent issues within this field. With a unified definition and a tool to consistently and quantitatively measure such instability, progression tracking of ankle instability within an individual following recurring injuries can be completed. The benefit from this is two-fold. Tracking instability will give further insight into the severity stratifications of ankle instability as well as the different types of instability (i.e., lateral, medial). Additionally, investigation into patient outcomes following differing treatments such as surgery versus non-operative, conservative measures would enable a path towards more informed patient treatment options and decisions aided by suggested instability parameter ranges for such treatments. Additionally, this tool could be used to train orthopedic trainees and to retrain orthopedic professionals, addressing two issues: standardization within training and reliability of orthopedic professional evaluation. All of these abilities would provide orthopedic physicians with the needed standardization within their practices, evaluations, decisions, and resultant patient outcomes. Additionally, this tool could be utilized in medically underserved areas, addressing the issue of access to specialized orthopedic evaluation of ankle instability.

Innovation in the orthopedic space may appear to be overwhelming, but focused efforts back to the basics can prove to be the most successful and prominent innovations in medicine. Focused and collaborative research on ankle instability measurement will prove to be system-

changing, and hopefully followed by procedure and guideline reforms that will allow individuals to qualify for procedures when they need them, not too late or too early.

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