JURNAL IPTEK
MEDIA KOMUNIKASI TEKNOLOGI
homepage URL : ejurnal.itats.ac.id/index.php/iptek



A Mini-Review on Critical Factors in Determining Angle of Pull (AOP) and Assessment Tools in Physiotherapy

Ahmad Syazwan Ahmad Kamal[1], Lim Zhen Hong[1], Rabiatul Adawiah Abdul Rahman[2], Bahman Jamaluddin[2], Rudi Setiawan[3], Syamimi Shamsuddin[4]*

[1]School of Mechanical Engineering, Engineering Campus, Universiti Sains Malaysia, 14300, Nibong Tebal, Pulau Pinang, Malaysia

[2]Department of Physiotherapy, Faculty of Health Sciences, Universiti Teknologi MARA Cawangan Pulau Pinang, Bertam Campus, 13200 Kepala Batas, Pulau Pinang, Malaysia

[3]Department of Biomedical Engineering, Institut Teknologi Sumatera, Jl. Terusan Ryacudu, Way Huwi, Kec. Jati Agung, Kabupaten Lampung Selatan, Lampung 35365, Indonesia

[4]Department of Community Health, Advanced Medical and Dental Institute, Universiti Sains Malaysia, Kepala Batas, Pulau Pinang, Malaysia

ARTICLE INFORMATION

Jurnal IPTEK – Volume 29
Number 2, December 2025

Page:
277 – 284
Date of issue:
December 30, 2025

DOI:
10.31284/j.iptek.2025.v29i2.7507

E-MAIL

syazwan@usm.my
syamimi.s@usm.my

*Corresponding author:
Syamimi Shamsuddin
syamimi.s@usm.my

PUBLISHER

LPPM- Adhi Tama Institute of Technology Surabaya

ABSTRACT

The Angle of Pull (AOP) is an essential concept in physiotherapy since it determines the efficiency of rehabilitation exercises by ensuring targeted muscle engagement and optimal force application. Therefore, precise quantification of AOP as well as identification of Range of Motion (ROM) and resistance points is critical when establishing appropriate rehabilitation strategies. However, traditional methods like the universal goniometer are most used but there are certain limitations such as the parallax error and inter-rater variability which can impact the precision required in clinical settings. This mini review examines the foundational elements of ROM, baseline muscle strength, and the resistor point in determining AOP. It also assesses the strength and weakness of the available tools, like the digital HALO goniometer and the AnglePro which is the goniometer that also has laser pointer for identifying the point of resistance. Despite technological advancements, current devices still exhibit significant limitations such as high costs, dependency on traditional goniometers, and lack of comprehensive functionality. The review points out the need for a new precise device that could capture the ROM, AOP and identify specific resistance points as effectively as a digital device but at a lower cost. Such innovations would facilitate the efficiency, accuracy and effectiveness of physiotherapy practice to improve patient results. Moreover, further exploration in this area is needed to eliminate the current shortcomings and develop the above strategies.

Keywords: *Angle-of-pull; physiotherapy; goniometer*

ABSTRAK

Sudut Tarikan (AOP) adalah konsep penting dalam fisioterapi kerana ia menentukan keberkesanan latihan pemulihan dengan memastikan penglibatan otot yang disasarkan dan aplikasi daya yang optimum. Oleh itu, pengukuran tepat AOP serta pengenalpastian Julat Pergerakan (ROM) dan titik rintangan adalah kritikal apabila menetapkan strategi pemulihan yang sesuai. Walau bagaimanapun, kaedah tradisional seperti goniometer universal paling kerap digunakan tetapi terdapat beberapa had seperti ralat paralaks dan kebolehubahan antara penilai yang boleh menjejaskan ketepatan yang diperlukan dalam persekitaran klinikal. Ulasan ringkas ini mengkaji elemen asas ROM, kekuatan otot asas, dan titik rintangan dalam menentukan AOP. Ia juga menilai kekuatan dan kelemahan alat yang tersedia, seperti goniometer digital HALO dan AnglePro yang merupakan goniometer yang

Address:
Jl. Arief Rachman Hakim No. 100, Surabaya 60117, Tel/Fax: 031-5997244

Jurnal IPTEK by LPPM-ITATS is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

juga mempunyai penunjuk laser untuk mengenal pasti titik rintangan. Walaupun terdapat kemajuan teknologi, peranti semasa masih menunjukkan had yang ketara seperti kos yang tinggi, kebergantungan pada goniometer tradisional, dan kekurangan fungsi yang menyeluruh. Ulasan ini menunjukkan keperluan untuk peranti tepat baharu yang boleh menangkap ROM, AOP dan mengenal pasti titik rintangan tertentu dengan berkesan seperti peranti digital tetapi pada kos yang lebih rendah. Inovasi sedemikian akan memudahkan kecekapan, ketepatan dan keberkesanan amalan fisioterapi untuk meningkatkan hasil pesakit. Selain itu, penerokaan lanjut dalam bidang ini diperlukan untuk menghapuskan kekurangan semasa dan membangunkan strategi di atas.

Kata Kunci: *Sudut tarikan; fisioterapi; goniometer*

INTRODUCTION

Angle of Pull (AOP) is one of the primary concepts in physiotherapy especially when it comes to the process of rehabilitation. AOP is defined as the angle between the vector of muscle force produced by the muscle and a straight line joining the centre of rotation of the joint to the muscle insertion [1]. Accurate determination of the AOP is crucial for ensuring targeted muscle engagement and optimal force application which are vital in developing effective rehabilitation programs. The significance of AOP can be shown in its ability to help tailor rehabilitation exercises to the specific needs of patients who are recovering from musculoskeletal injuries or neurological disorders [2].

Three principles are critical to the process of identifying and implementing the AOP in physiotherapy which includes Range of Motion (ROM), Base Muscle Strength and Resistor Point. ROM refers to the full movement potential of a joint, typically its range of flexion and extension. It is essential to take an accurate ROM measurement in order to determine the AOP so that therapeutic exercises are aligned with the patient's physical capabilities [3].

Baseline Muscle Strength provides a reference point to assess the effectiveness of rehabilitation exercises and monitor the rehabilitation progress [3]. Understanding the baseline strength allows for the precise calibration of exercises to match the patient's current capabilities and minimized the risk of overexertion or underutilization of muscles.

The Resistor Point where maximum resistance occurs during a therapeutic exercise is crucial for determining the exact AOP. When aiming to produce maximal torque from a muscle, it is essential to position the joint so that the muscle being worked has a 90° angle of pull on the extremity. This principle ensures that the muscle exerts maximum force which is critical for effective rehabilitation and strengthening exercises. This mini review will explore these foundational elements ROM, Baseline Muscle Strength, and the Resistor Point used to determine AOP. It will also discuss existing market products that aim to improve the accuracy and efficiency of AOP determination.

LITERATURE REVIEW

Range of Motion (ROM)

Range of motion (ROM) is a basic characteristic of human movement and functional capability, which refers to the degree of motion that is available at a joint [4]. It is a critical factor in joint health, injury prevention and performance of normal daily activities. The ROM is central for the examination and discussion on human motion, including the use of terminology and measurement in the field. It has been found very useful in diagnosing and monitoring the mobility of joints, muscles, bones, and the overall body systems. The dysfunction of the neural or musculoskeletal systems may cause a joint to be hypomobile or hypermobile [5]. Understanding the intricacies of ROM and its influencing factors is essential for healthcare professionals, fitness experts, and individuals seeking to optimize their physical well-being. It can be categories into 5 types of motion including active, passive, assisted, active-assisted, and resisted. Active motion originates from the individual's own muscular exertion, akin to lifting an arm. In contrast, passive motion is initiated by an external force without the involvement of voluntary muscle contraction, [6]as observed in joint manipulation during physical therapy [7][8]. Assisted motion incorporates external assistance,

typically through the guidance of a therapist, to aid in movement. Active-assisted motion combines voluntary muscle contraction with external assistance, fostering a collaborative effort for enhanced range of motion[9]. Resisted motion involves working against an external force, commonly employed in strength training.

Active range of motion (AROM) plays a critical role in defining the midpoint of muscles, a crucial factor for optimizing muscle function and efficiency. To facilitate movement and locomotion, both humans and animals produce joint moments by transferring forces from muscles to bones. The ability of muscles to generate force at different joint angles is primarily influenced by the muscle's optimal length which also known as the midpoint [10]. The midpoint, also known as the muscle's optimal length or resting length is the position where a muscle can generate the maximum force during contraction [11]. Understanding AROM is crucial because it includes the range in which muscles can actively contract and move joints. Identifying the midpoint, where a muscle can generate the most force, is especially important as it directly impacts the muscle's efficiency. When AROM is limited due to joint stiffness or muscle imbalances, pinpointing this midpoint becomes important for effective rehabilitation and therapy.

Muscle length is an important factor in determining force and tension. The full range (AROM) is where a muscle can work within the range between the position of maximal stretch to the position of maximal shortening. The AROM can be divided to 3 different range which is the outer range, inner range, and mid-range (midpoint) [1]. The outer range is the muscle working in maximally stretched position which move between longest length and mid-point of range and has the least tension produce. The inner range is the muscle working in maximally shortened position which moves between the shortest length and mid-point of range and least force generated. Meanwhile, the middle range is the muscle working between mid-point of outer range and mid-point of inner range which has the maximum tension generated [3]. In rehabilitation, it is imperative to identify and establish the midpoint as the reference starting point for the entire process. This ensures that muscle-strengthening exercises encompass the range where maximal tension is generated.

In rehabilitation, the midpoint of the range of motion (ROM) serves as a reference point for various assessments and exercises [4]. While the entire range of motion is important, the midpoint has specific significance in rehabilitation for several reasons such as baseline assessment which serves as the reference for assessing the initial status of a joint's flexibility and mobility [3]. As rehabilitation progresses, regular assessments at the midpoint become a compass for healthcare professionals, facilitating the tracking of advancements or constraints in joint movement and guiding necessary adjustments in interventions and goal setting. Moreover, the midpoint also serves as the starting point for prescribing specific rehabilitation exercises which frequently target the midpoint to address muscle strength, flexibility, and control within that specific range. Therefore, this shows that muscle length and the angle of pull are intricately related as the efficiency of muscle contraction and force generation is contingent on the optimal length of a muscle, and the angle of pull, representing the angle between the muscle's line of action and the bone perpendicular, influences the effectiveness of muscle contraction, with optimal force production occurring at a specific angle.

Baseline Muscle Strength

Muscle strength, a fundamental aspect of human movement and functional capacity, refers to the ability of a muscle to exert force against resistance. It plays a crucial role in performing everyday tasks, maintaining balance and coordination, and preventing injuries. Understanding baseline muscle strength, the inherent strength of a muscle without training or conditioning, is essential for evaluating an individual's functional capacity, identifying potential health risks, and designing effective exercise programs.

In rehabilitation, establishing the baseline muscle strength using the non-injured hand is crucial. Establishing the initial strength level (repetition maximum RM) of the non-injured hand serves as a crucial baseline for the rehabilitation to recover the strength of the injured hand. This comparative analysis helps customize a rehabilitation program for the unique needs of the injured hand. By comparing it with the non-injured hand, physiotherapists can accurately measure how much weaker the injured hand is in terms of muscle strength. This helps them design specific exercises to

restore balance and function effectively [12]. The baseline muscle strength, measured with the non-injured hand not only directs how intense and advanced the rehabilitation should be but also offers a clear measure to track improvements over time. This approach ensures that the rehabilitation program is intricately designed, allowing for optimal recovery and the gradual strengthening of the injured hand in alignment with its non-injured counterpart.

Repetition maximum RM is defined as the greatest amount of weight (load) a muscle can move through the available range of motion (ROM) a specific number of times [13]. In rehabilitation, having accurate RM serve as a basis for task-specific practice, as well as muscle conditioning to ultimately facilitate functional outcomes. For example, repetitions of movements involving the arms may strengthen the arms and help the patient to learn correct movements to reduce the increased potential for musculoskeletal injury[14]. Therefore, in the baseline assessment, by determining the repetitive movements (RM) of the non-injured arm as a reference and comparing it with the RM of the injured hand, physiotherapists can tailor a specific rehabilitation program for that patient.

Angle of Pull (AOP)

Angle of Pull (AOP) is the angle created by the muscle's line of pull and the bone's longitudinal axis where the muscle is active. Typically determined by the joint angle, this aspect significantly influences the muscle's strength. Maximum tension exerted by a muscle occurs only at specific angles of pull. To address variations in muscular tension at different joint angles, exercise machines with variable resistance are designed to adapt and provide consistent resistance throughout the range of motion [15].

In rehabilitation, the intricate relationship between AOP, baseline strength assessment and range of motion is a critical consideration. When evaluating baseline strength of a muscle, the AOP directly influences the efficiency of force generation within the muscle. In assessments of baseline strength, it is common to examine how muscles generate force at joint angles. Ensuring the optimal alignment of the AOP during these evaluations guarantees precise and significant measurements of an individual's starting strength [16][17].

At the same time, the AOP is intimately connected to evaluations of range of motion, which assess the joint's ability to navigate different angles. The engagement of muscle fibres during movement is also greatly influenced by the AOP. In rehabilitation, tailoring exercises to align with ideal AOP improve muscle activation and enhance overall joint flexibility and function[18]. By improving the muscle strength through tailored exercise at specific AOP for muscle injuries patient can help to recover and improve the ROM of the muscle [19].

Resistor Point

The concept of the angle of pull is fundamental in therapeutic exercise and strength training. When aiming to produce maximal torque from a muscle, it is essential to position the joint so that the muscle being worked has a 90° angle of pull on the extremity. This principle ensures that the muscle exerts maximum force, which is critical for effective rehabilitation and strengthening exercises.

This concept is equally important for external forces applied to the body. For example, in pulley systems, the maximal resistance occurs when the angle of pull of the pulley's rope is 90° relative to the extremity being resisted. This is because the 90° angle allows for the optimal application of force, maximizing the effectiveness of the exercise.

Similarly, when using free weights, the maximal resistance is achieved when the pull of the weight is perpendicular to the ground, regardless of the extremity’s position. In this scenario, the line of pull of the weight is 90° to the ground. For example, when a supine patient performs elbow flexion with a weight, the greatest resistance is at the start of the motion when the elbow moves from full extension to flexion. However, if the patient is standing or sitting, the maximal resistance from the weight occurs when the elbow is at 90°.

The concept of the resistor point is key to ensuring maximal muscle torque. The resistance point is a critical concept in therapeutic exercise and strength training. It refers to the specific location where resistance is applied to ensure that the line of pull of the muscle or external force forms a 90° angle with the extremity being exercised. This 90° angle is optimal because it allows for maximal torque production by the muscle.

In practical terms, this means that when a patient is performing an exercise, such as elbow flexion with a weight, the greatest resistance is encountered when the elbow is at a 90° angle. This is because the muscle can exert maximal tension at this angle of pull, making the exercise most effective at this point. Variable resistance exercise machines are designed to adjust the resistance throughout the range of motion, ensuring that the resistance point consistently allows for maximal muscle torque by compensating for the variations in muscular tension at different joint angles.

In summary, the resistance point is the specific location where resistance is applied to ensure the line of pull achieves an optimal angle, usually 90°, to produce maximal muscle torque. This principle is vital in therapeutic exercise and strength training, allowing for the most effective rehabilitation and strengthening outcomes.

METHOD

This mini review was conducted to explore the key factors influencing the Angle of Pull (AOP) and the available tools used for its measurement in physiotherapy. A targeted literature search was performed using Google Scholar, and Scopus to identify relevant articles discussing AOP, Range of Motion (ROM), baseline muscle strength, and resistance points in rehabilitation. The search terms included "Angle of Pull in physiotherapy," "Range of Motion measurement," "muscle strength assessment," and "goniometer accuracy."

Only studies or innovations that provided insight into the practical application and measurement of AOP in physiotherapy were included. Preference was given to articles discussing commonly used tools, such as the universal goniometer, HALO digital goniometer, and the AnglePro. The review also considered studies comparing the accuracy and limitations of these devices. Non-English studies and those unrelated to rehabilitation or physiotherapy were excluded to maintain relevance. The findings from the selected literature were summarized in a simple comparison of available measurement tools to highlight their advantages and drawbacks.

Comparison of Products in the Market for ROM and AOP

Among all the instruments available in the field of physiotherapy, the universal goniometer is widely used to measure the ROM and AOP. It has become widely used due to its relatively low cost and high accuracy compared to other methods, for example, visual estimate. However, the universal goniometer has its limitations.

One significant challenge associated with the universal goniometer is the potential for measurement errors, such as parallax error. This is one of the main errors that are associated with the scale readings whereby the results are inaccurate due to the inclination of the scale to an angle. Moreover, the standard goniometer has one-degree gradations, which might not be precise enough to capture small changes in the ROM, especially in research settings. The time-consuming nature of using a universal goniometer to determine AOP further complicates its use in clinical practice. Also, in the case when different healthcare professionals are performing the test using the scale, the differences in the technique and interpretation of the scale can lead to variation in the ROM, known as the inter-rater variability.

However, these limitations have been evident in recent years with the emergence of new devices that are intended to solve part of these problems. For instance, the HALO, a digital dual goniometer designed to provide precise readings for both ROM and AOP within a shorter period[20]. While the HALO offers significant advantages in terms of accuracy, it comes at a high cost, making it less accessible to many physiotherapists, particularly those in training. Table 1 provides a comparison between the HALO and the AnglePro, highlighting their respective strengths and limitations.

Table 1. Comparison between HALO and AnglePRO

Authors & Reference	Type of Product	Price	Limitations
[20] Correll *et. al.* (2018)	Digital dual goniometer; provides precise readings for both ROM and AOP.	High	Cost-prohibitive for many users, especially physiotherapists in training Lack of ability to pinpoint resistor point.
[21] Rahman *et. al.* (2017)	Goniometer with integrated laser pointer; designed to pinpoint the resistance point after determining AOP	Low	Relies on traditional goniometer for ROM and AOP measurement, potentially leading to errors such as parallax error.

Discussion

Limited studies were found to support the precise determination of Angle of Pull (AOP) and the accurate location of the resistance point in physiotherapy which underscores a significant gap in the existing literature and technology. Despite the extensive use of traditional tools such as the universal goniometer for determining Range of Motion (ROM) and AOP, these instruments have notable limitations that can impact measurement accuracy and consequently, the effectiveness of rehabilitation programs. Despite being affordable, readily available, and portable, the universal goniometer is imprecise when it comes to measuring small changes in ROM, has inherent parallax errors, and is sensitive to intra and inter-rater variability due to differences in technique and interpretation.

To address these challenges, innovations such as the HALO have been developed and introduced. The HALO offers enhanced accuracy in measuring both ROM and AOP using digital sensors which significantly reduces human error. A recent validation study also confirmed that HALO demonstrated high reliability in ROM assessment while effectively minimizing inter-rater differences—an issue commonly associated with traditional tools like the universal goniometer [22]. However, despite its technical advantages, HALO is expensive, especially for students and small clinics and it lacks the capability to pinpoint the resistance point which is a critical factor in optimizing therapeutic exercises.

The AnglePro, developed as an innovative response to the need for pinpointing resistance points, attempts to bridge this gap by incorporating a laser indicator to identify the resistance location after determining the AOP. Nonetheless, the AnglePro continues to rely on the traditional goniometer for ROM and AOP measurements, thus inheriting the limitations of traditional methods, such as potential parallax error.

This analysis highlights the need for further advancements in physiotherapy tools that integrate high accuracy in both ROM and AOP measurements while also offering the ability to pinpoint resistance points. An ideal solution would combine the precision of digital technology with the comprehensive functionality needed to enhance the efficacy and efficiency of physiotherapy practices, all while remaining accessible to a broad range of users.

CONCLUSION

In summary, the existing methods, and devices for determining the Angle of Pull (AOP) and locating resistance points in physiotherapy exhibit both strengths and limitations. The universal goniometer remains prevalent due to its cost-effectiveness but is hindered by measurement inaccuracies and variability among practitioners. While digital tools like the HALO have enhanced measurement accuracy for ROM and AOP, their high cost and inability to pinpoint resistance points restrict their accessibility and utility. The AnglePro offers a partial solution by addressing the need to identify resistance points but still depends on traditional techniques for ROM and AOP measurements, thereby inheriting their limitations.

These observations highlight a clear need for the development of a comprehensive device that can accurately measure both ROM and AOP while also precisely identifying resistor point, all at an affordable cost. Such an innovation would greatly improve the accuracy and effectiveness of physiotherapy practices, ultimately leading to better patient outcomes. Continued research and development in this field are crucial to overcoming the current limitations and advancing rehabilitation technology.

ACKNOWLEDGEMENT

The authors are grateful to the Physiotherapy Department at the Faculty of Health Sciences, Universiti Teknologi MARA (UiTM) Bertam, Pulau Pinang for the support provided during this study.

BIBLIOGRAPHY

[1] M. Kent, "The Oxford Dictionary of Sports Science & Medicine - 'Cognitive Learning,'" *The Oxford Dictionary of Sports Science & Medicine*, 2007.

[2] C. G. Mattacola and M. K. Dwyer, "Rehabilitation of the Ankle After Acute Sprain or Chronic Instability," *Journal of Athletic Training*, vol. 37, no. 4, p. 413, 2002.

[3] H. M. Clarckson, "Musculoskeletal Assesment Joint Motion," pp. 332–339, 2013.

[4] P. Page, "Current Concepts in Muscle Stretching for Exercise and Rehabilitation," *International Journal of Sports Physical Therapy*, vol. 7, no. 1, p. 109, Feb. 2012.

[5] S. T. Abu El Kasem, S. M. Aly, E. M. Kamel, and H. M. Hussein, "Normal active range of motion of lower extremity joints of the healthy young adults in Cairo, Egypt," *Bulletin of Faculty of Physical Therapy*, vol. 25, no. 1, Dec. 2020, doi: 10.1186/S43161-020-00005-9.

[6] D. L. Millis and D. Levine, "Range-of-Motion and Stretching Exercises," *Canine Rehabilitation and Physical Therapy: Second Edition*, pp. 431–446, 2013, doi: 10.1016/B978-1-4377-0309-2.00025-9.

[7] J. D. Trinity and R. S. Richardson, "Physiological Impact and Clinical Relevance of Passive Exercise/Movement," *Sports medicine (Auckland, N.Z.)*, vol. 49, no. 9, p. 1365, Sep. 2019, doi: 10.1007/S40279-019-01146-1.

[8] L. J. Klein, "Evaluation of the Hand and Upper Extremity," *Fundamentals of Hand Therapy: Clinical Reasoning and Treatment Guidelines for Common Diagnoses of the Upper Extremity: Second Edition*, pp. 67–86, 2013, doi: 10.1016/B978-0-323-09104-6.00005-5.

[9] A. Pollock *et al.*, "Physical rehabilitation approaches for the recovery of function and mobility following stroke," *The Cochrane Database of Systematic Reviews*, vol. 2014, no. 4, Apr. 2014, doi: 10.1002/14651858.CD001920.PUB3.

[10] A. Kruse, C. Rivares, G. Weide, M. Tilp, and R. T. Jaspers, "Stimuli for Adaptations in Muscle Length and the Length Range of Active Force Exertion—A Narrative Review," *Frontiers in Physiology*, vol. 12, p. 742034, Oct. 2021, doi: 10.3389/FPHYS.2021.742034.

[11] K. C. Nishikawa, J. A. Monroy, and U. Tahir, "Muscle Function from Organisms to Molecules," *Integrative and Comparative Biology*, vol. 58, no. 2, pp. 194–206, Aug. 2018, doi: 10.1093/ICB/ICY023.

[12] Carolyn. Kisner and L. Allen. Colby, "Therapeutic exercise : foundations and techniques," p. 023, 2012.

[13] "The Oxford Dictionary of Sports Science & Medicine," *The Oxford Dictionary of Sports Science & Medicine*, Jan. 2006, doi: 10.1093/ACREF/9780198568506.001.0001.

[14] D. Zbogar, J. J. Eng, W. C. Miller, A. V. Krassioukov, and M. C. Verrier, "Movement Repetitions in Physical and Occupational Therapy during Spinal Cord Injury Rehabilitation," *Spinal cord*, vol. 55, no. 2, p. 172, Feb. 2017, doi: 10.1038/SC.2016.129.

[15] "The Oxford Dictionary of Sports Science & Medicine," *The Oxford Dictionary of Sports Science & Medicine*, Jan. 2006, doi: 10.1093/ACREF/9780198568506.001.0001.

[16] M. D. Jakobsen *et al.*, "Muscle Activity During Knee-Extension Strengthening Exercise Performed with Elastic Tubing and Isotonic Resistance," *International Journal of Sports Physical Therapy*, vol. 7, no. 6, p. 606, Dec. 2012.

[17] R. Davison *et al.*, *Sport and exercise physiology testing guidelines. Volume I, Sport testing : the British Association of Sport and Exercise Sciences guide*.

[18] E. M. Arnold, S. R. Hamner, A. Seth, M. Millard, and S. L. Delp, "How muscle fiber lengths and velocities affect muscle force generation as humans walk and run at different speeds," *The Journal of Experimental Biology*, vol. 216, no. 11, p. 2150, Jun. 2013, doi: 10.1242/JEB.075697.

[19] H. Zarei, A. A. Norasteh, and M. Koohboomi, "The Relationship Between Muscle Strength and Range of Motion in Lower Extremity With Balance and Risk of Falling in Elderl," *Physical Treatments - Specific Physical Therapy Journal*, vol. 10, no. 1, pp. 33–40, Jan. 2020, doi: 10.32598/PTJ.10.1.430.1.

[20] S. Correll, J. Field, H. Hutchinson, G. Mickevicius, A. Fitzsimmons, and B. Smoot, "Reliability and Validity of The Halo Digital Goniometer for Shoulder Range of Motion in Healthy Subjects," *International Journal of Sports Physical Therapy*, vol. 13, no. 4, p. 707, Aug. 2018, doi: 10.26603/ijspt20180707.

[21] R. A. A. Rahman, N. A. M. Shipah, and B. Jamaluddin, "Angle of Pull Resistance Point Locater: AnglePRO," no. 2017, 2023.

[22] A. R. Wilson-Smith, S. Muralidaran, M. Maharaj, M. H. Pelletier, P. Beshara, P. Rao, L. M. Pearce, T. Wang, R. J. Mobbs, and W. R. Walsh. Validation of a novel range of motion assessment tool for the cervical spine: the HALO© digital goniometer. Journal of spine surgery (Hong Kong), 8(1), 93–102. https://doi.org/10.21037/jss-21-92, 2022