Health Problems of Civilization
eISSN: 2354-0265, ISSN: 2353-6942

ORIGINAL PAPER

ASSESSING THE AWARENESS OF DIFFERENT METHODS OF MEASURING QUADRICEPS LAG AMONG PHYSIOTHERAPISTS IN INDIA: A CROSS-SECTIONAL OBSERVATIONAL SURVEY

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Kumari S, Kakkad AD. Assessing the awareness of different methods of measuring quadriceps lag among physiotherapists in India: a cross-sectional observational survey. Health Prob Civil. https://doi.org/10.5114/hpc.2025.152299

Tables: 3

Figures: 5

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Submitted: 2025 May 23

Accepted: 2025 Jun 23

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eISSN: 2354-0265, ISSN: 2353-6942

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Summary

Background. Accurate assessment of quadriceps lag is essential in musculoskeletal rehabilitation to restore function and prevent long-term disability. This study aimed to evaluate physiotherapists' awareness, familiarity, and use of various quadriceps lag measurement methods.

Material and methods. A cross-sectional survey was conducted among 247 physiotherapists across Gujarat, India, between March and July 2023. Data was collected using a structured online questionnaire and analyzed using descriptive statistics.

Results. Most participants (96%) were aware of quadriceps lag. Goniometry and visual estimation were the most recognized and frequently used methods. Inclinometers, smartphone-based goniometers, wearable biofeedback devices, and advanced imaging methods were less familiar. Some respondents mentioned alternative techniques like tape measurements and gait lab analysis. The majority emphasized the importance of accurate measurement and expressed interest in learning more, particularly through written materials and recordings.

Conclusions. While general awareness of quadriceps lag is high, knowledge of objective and advanced measurement tools remains limited. Targeted educational efforts could improve clinical assessment practices and enhance rehabilitation outcomes, contributing to better management of musculoskeletal disorders.

Keywords: quadriceps muscle, range of motion, cross-sectional studies, physical therapists, surveys and questionnaires

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eISSN: 2354-0265, ISSN: 2353-6942

Introduction

Primarily due to sedentary lifestyles, increased screen time, and aging demographics, musculoskeletal disorders (MSDs) have emerged as a significant global public health concern [1]. Functional decline is mostly associated with quadriceps dysfunction, a common impairment in conditions such as knee osteoarthritis, post-surgical recovery, and neurological injuries. Persistent quadriceps strength deficits, particularly after injuries like anterior cruciate ligament (ACL) reconstruction, can impair mobility, contribute to chronic knee dysfunction, and delay a return to activity. Meta-analytic evidence shows that such deficits may remain up to one year post-rehabilitation and significantly influence joint biomechanics and recovery outcomes [2]. The implications extend beyond individual health, as the increasing demand for long-term care and rehabilitation services places significant strain on healthcare systems [3].

The inability of a patient to actively achieve full knee extension, despite the joint's capacity for passive extension, is referred to as quadriceps lag [4]. This issue is clinically significant for assessing knee joint function and often indicates neuromuscular inhibition or weakness of the quadriceps muscle. The diagnosis and monitoring of conditions such as ACL tears, patellofemoral pain syndrome, and knee osteoarthritis rely on precise assessment of quadriceps lag. These illnesses are more prevalent due to aging populations, sedentary lifestyles, and less physical exercise, all of which are closely associated with contemporary societal health challenges. Proper assessment enables the evaluation of functional outcomes, the formulation of treatment plans, and the advancement of rehabilitation. Among the quadriceps group, the vastus medialis obliquus (VMO) plays a particularly vital role in achieving the terminal phase of knee extension. Weakness, atrophy, or poor neuromuscular activation of the VMO can significantly contribute to quadriceps lag by failing to generate adequate extension torque in the final degrees of motion. Its timely activation is essential not

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eISSN: 2354-0265, ISSN: 2353-6942

only for joint mechanics but also for patellar stabilization and functional recovery following injury or surgery [2].

Numerous methodologies are available in clinical physiotherapy to assess active knee range of motion and quadriceps lag. Recent study demonstrates significant validity in goniometric tests when compared with radiographic methods, affirming their reliability for assessing joint mobility [5]. This validates their continued use in tele-rehabilitation and clinical environments. Smartphone-based goniometer applications have demonstrated strong validity and reliability in clinical use, offering accurate angle measurement for knee flexion and extension, and providing a feasible alternative to traditional tools [6]. Wearable real-time monitoring devices [7] and digital photography [8] present new opportunities. In recent years, the use of ubiquitous technology has considerably improved rehabilitation practices by allowing for personalized feedback and continuous monitoring. Therapists can now monitor functional enhancements remotely, which enhances adherence and outcomes in home-based settings, thanks to devices like inertial sensors and EMG-integrated systems [8]. Innovative 3D teleconferencing systems have potential in strengthening the level of accuracy of remote physical evaluations, especially for postural and kinematic assessments, which may improve tele-rehabilitation results [9]. Various instruments exhibit differing levels of accuracy, accessibility, cost, and ease of use, which influence their adoption in routine clinical practice.

Despite alternative approaches, there is a lack of information about physiotherapists' real understanding, familiarity, or use of these devices. Given the increasing prevalence of musculoskeletal illnesses associated with modern lifestyles, addressing knowledge deficiencies, enhancing professional competencies, and promoting consistent, evidence-based treatments need an understanding of current practices.

Insufficient evaluation processes in clinical and rehabilitative settings result in significantly lower patient outcomes. Successful rehabilitation and recovery monitoring need

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eISSN: 2354-0265, ISSN: 2353-6942

an objective and regular assessment of quadriceps strength and function. In contrast, an overreliance on subjective assessments or inconsistent measurement procedures can prevent the early discovery of impairments, lengthen recovery times, and result in the use of suboptimal rehabilitation treatments. Such shortcomings often result in a decreased quality of life for patients, less physical activity, and insufficient muscle function recovery. A recent study suggests that synthetic grafts may improve post-operative rehabilitation following ACL repair, with a faster return to sports and more psychological preparation than traditional allografts [10].

Despite the emergence of advanced technology such as wearable sensors for precise, real-time monitoring of muscle function and smartphone applications, their use in routine clinical practice remains limited. The use of these technologies is obstructed by obstacles such as ignorance, insufficient training of healthcare staff, and integration issues with existing protocols [11]. Utilizing these modern measurement methods may enhance accuracy, enable personalized therapy, and ultimately improve patient outcomes, therefore reducing the broader societal and economic consequences of musculoskeletal disorders.

Aim of the work

The aim of this study was to assess the awareness of different methods of measuring quadriceps lag among physiotherapists in India.

The objectives of the study include:

1. assessing the awareness level of the respondents regarding the concept of quadriceps lag measurement,
2. identifying the commonly recognized methods used by the respondents to measure quadriceps lag,

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eISSN: 2354-0265, ISSN: 2353-6942

3. evaluating the familiarity of the respondents with different methods for measuring quadriceps lag,
4. determining the personal experience of the respondents in using or witnessing the use of different methods for measuring quadriceps lag,
5. identifying any additional methods or techniques known to the respondents for measuring quadriceps lag,
6. assessing the perceived importance of accurately measuring knee joint range of motion in medical or rehabilitation settings among the respondents,
7. determining the interest of the respondents in learning more about different methods of measuring knee joint range of motion,
8. identifying the preferred channels through which the respondents would like to receive information about measuring knee joint range of motion.

Material and methods

Study design

This study was a cross-sectional observational survey conducted using a self-administered online questionnaire.

Study population and sampling

A total of 247 physiotherapists practicing in diverse clinical settings across Gujarat, India, were recruited through purposive sampling. Data was collected over five months, from March to July 2023.

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Survey tool

A structured questionnaire was developed and distributed via Google Forms. The questionnaire included both closed-ended and open-ended questions focusing on awareness, familiarity, and utilization of different quadriceps lag measurement methods. It also covered perceived importance and preferred modes of learning about these methods.

Data collection

The survey was disseminated through social media and e-mail platforms. Responses were automatically recorded in Google Forms and exported to Microsoft Excel for analysis.

Data analysis

The survey responses were compiled using Google Forms and exported to Microsoft Excel (Version 2504, Build 18730.20168, Microsoft Corp., Redmond, WA, USA). Descriptive statistics, including frequencies and percentages, were used to summarize participants' demographic details, awareness levels, and utilization of various quadriceps lag measurement methods. No inferential statistical tests were applied in this study, as the analysis was limited to descriptive evaluation only.

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Results

Section 1: Demographic details of the respondents

Table 1 lists the participant profile. The respondents ranged in age, mostly in early to mid-career phases. Most of the female participants had less than five years of clinical experience and had a bachelor's degree in physiotherapy. Clinical environments varied, with the most prevalent places of employment being private clinics and hospitals.

Table 1. Demographic characteristics of the participants (N=247)

Category	Variable	Number of participants (%)
Age (in years)	**Under 25**	96 (38.9)
	25-34	105 (42.5)
	35-44	39 (15.8)
	45-54	5 (2.0)
	55+	2 (0.8)
Gender	**Male**	110 (44.5)
	Female	137 (55.5)
Education	**BPT**	145 (58.7)
	MPT	88 (35.6)
	PhD	14 (5.7)
Experience (in years)	**<5 years**	128 (51.8)
	5-10 years	79 (32.0)
	11+ years	40 (16.2)
Clinical setting	**Hospital**	92 (37.2)
	Private clinic	101 (40.9)
	Academic/Other	54 (21.9)

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Section 2: Familiarity with and awareness of quadriceps lag measurements

Figure 1 shows that almost all the respondents knew of the quadriceps lag measurement. Among the many instruments, goniometry and visual estimate were the most often used (Figure 2).

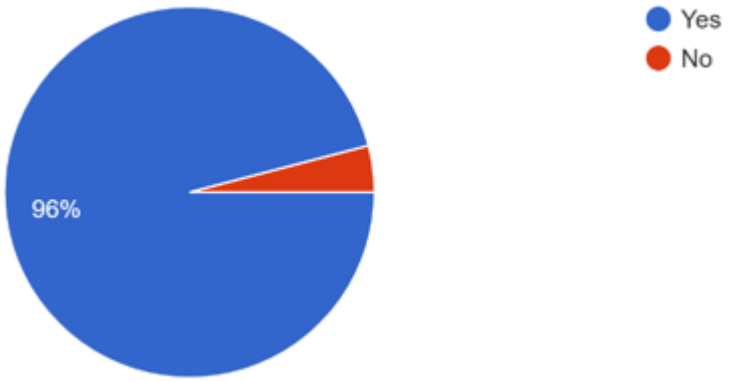

Figure 1. Awareness of quadriceps lag measurement

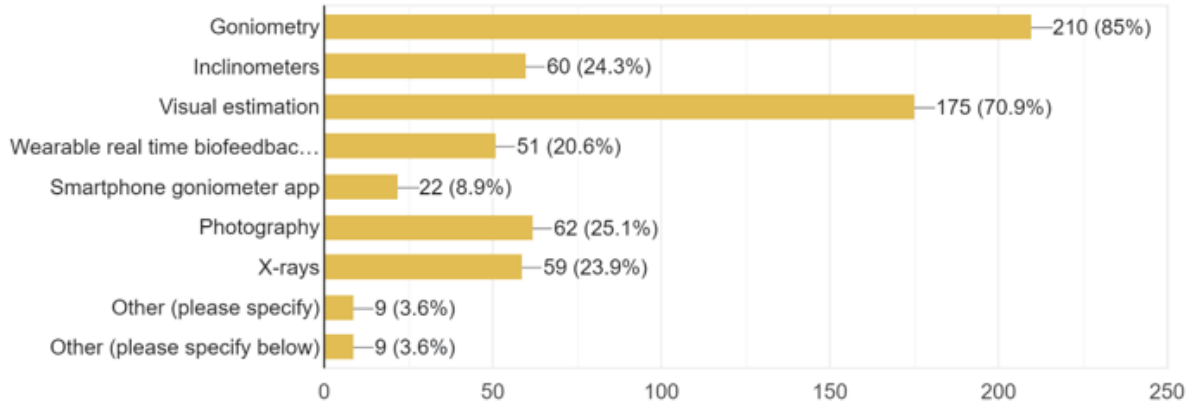

Figure 2. Commonly recognized methods to measure quadriceps lag

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Table 2 lists personal knowledge and practical expertise with standard measuring instruments. While inclinometers were less popular and seldom utilized, goniometry and visual estimating stood out as both well-known and were most often employed in practice.

Table 2. Familiarity and use of common tools among the physiotherapists (N=247)

Measurement method	Familiarity (%) (very/somewhat/not at all)	Used or observed in practice (%) (yes/no)
Goniometry	66.0/29.1/4.9	76.1/23.9
Inclinometers	10.5/42.9/46.6	14.2/85.8
Visual estimation	67.6/23.1/9.3	81.8/18.2

As Table 3 summarizes, less often utilized approaches like smartphone-based goniometer applications, photography, and sophisticated imaging techniques exhibited lower degrees of awareness and were typically not seen as regular instruments in clinical settings.

Table 3. Awareness and perceived common use of less common quadriceps lag measurement methods among the physiotherapists (N=247)

Measurement method	Familiarity (%) (very/somewhat/not at all)	Perceived as commonly used (%) (yes/no)
Smartphone goniometer apps	10.5/35.2/54.3	17.8/82.2
Photography	22.7/34.4/42.9	34.4/65.6
MRI or X-ray	23.1/35.2/41.7	30/70

Section 3: Perceived importance and learning preferences

As Figure 3 shows, the great majority of the participants in clinical and therapeutic settings thought precise assessment of quadriceps lag to be rather crucial. Throughout the

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eISSN: 2354-0265, ISSN: 2353-6942

sample, there was extreme interest in learning more about certain measuring techniques (Figure 4). When questioned about preferred routes for such information, participants favored multimedia forms, with textual guidelines and video lectures being scored most highly (Figure 5).

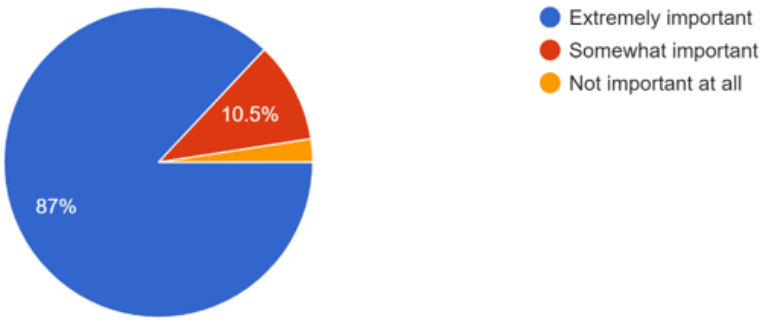

Figure 3. Perceived importance of quadriceps lag measurement

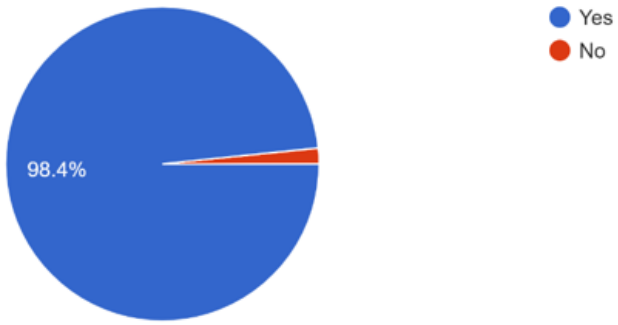

Figure 4. Interest in learning more about measurement methods

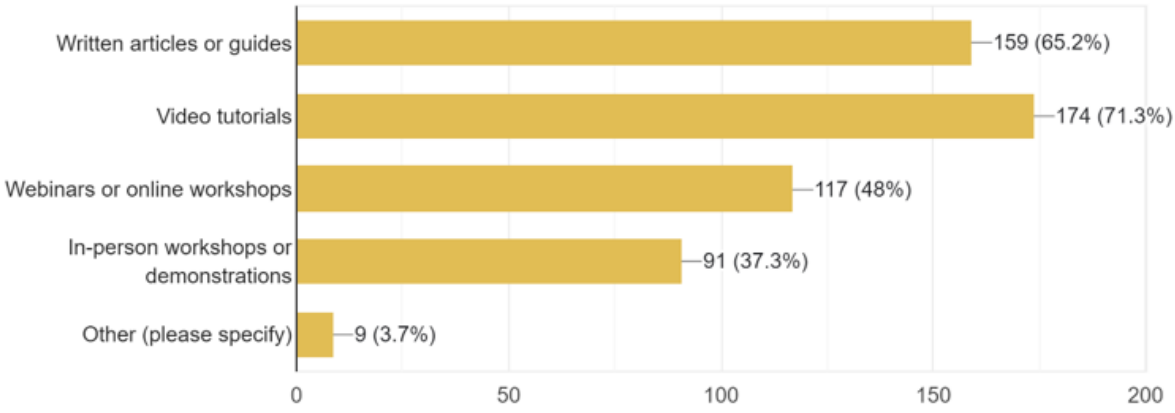

Figure 5. Preferred channels for receiving information

eISSN: 2354-0265, ISSN: 2353-6942

Discussion

Quadriceps lag measurement is an important tool for evaluating muscle imbalance and rehabilitation outcomes in the clinical and physiotherapy environments. This study seeks to assess the knowledge of physiotherapists concerning various quadriceps lag measurement methods. Through their level of familiarity with many measurement techniques and perceived usage, this discussion will provide insight into the existing knowledge and preferences among professionals.

The survey results indicated that the majority of the physiotherapists (96%) have heard of quadriceps lag measurement, demonstrating a high level of awareness within the profession. This aligns with the findings by Hancock et al. [12], who emphasized the significance of accurate joint angle measurement in rehabilitation, which likely contributes to physiotherapists' familiarity with methods like goniometry for assessing quadriceps lag.

Based on the answers, goniometry (85%) and visual estimation (70.9%) are seen as the most frequently utilized techniques for the assessment of quadriceps lag. Other techniques like inclinometers (24.3%) and photography (25.1%) were also identified but to a lesser degree. Surprisingly, wearable real-time biofeedback devices (20.6%) and smartphone goniometer apps (8.9%) are less known to the physiotherapists. These results are in line with Huhn et al. [13], who commented that although wearable technology holds promise for health studies, it remains underutilized in clinical practice.

The survey indicated that the physiotherapists use a range of techniques to quantify quadriceps lag, such as goniometry, scanograms, MRI and gait lab analysis, inch tape measurement, manual muscle testing, high sitting knee extension, instruments like voltmeters and sphygmomanometers, the finger method, reflective markers, and real-time feedback.

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A large percentage of the participants (66%) stated being very familiar with goniometry as a means to assess quadriceps lag. This indicates that goniometry is commonly known and presumably included in physiotherapy education and training. Recent research underlined the need of organized rehabilitation and the use of reliable tools—such as goniometers—to evaluate knee function and quadriceps strength, which are fundamental for optimum return to sport and psychological recovery following ACL revision surgery [10].

About three-quarters of the responders (76.1%) have used a goniometer for themselves or seen it used to assess quadriceps lag, which suggests hands-on familiarity with this procedure. The high usage rate corresponds to results from Jagodzinski et al. [14], who showed that goniometry is currently one of the most accepted and validated techniques for assessing knee joint angles in practice.

Contrary to goniometry, fewer physiotherapists (10.5%) reported that they were very familiar with the use of inclinometers. This implies that education or training may be necessary to improve awareness and understanding of this measurement instrument. Mohammad et al. [15] highlighted the reliability of digital inclinometers in joint range of motion measurement, proposing that such equipment can be effective when used in the practice of physiotherapy.

Different quadriceps lag assessment approaches are supported to varied degrees in scientific literature. Although often employed because of its simplicity, goniometry may lack accuracy in clinical studies including post-operative patients and shows very modest sensitivity in identifying small variations in knee extension. Especially at early phases of rehabilitation when improvement is limited but crucial [6,18], digital inclinometers and wearable sensor systems provide more sensitive and objective assessments. Wearable motion sensors have shown to be able to detect as low as 3-5 degrees of shift, which would not be perceived depending on visual estimation [16]. Although widely used in daily life, visual estimation is still a subjective technique with variations in observers that lowers its dependability in result

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eISSN: 2354-0265, ISSN: 2353-6942

monitoring [17]. Though having increasing validity, underutilization of extremely sensitive instruments such as smartphone applications and biofeedback-integrated sensors may restrict early identification of progress and tailored treatment planning. Whether for the first screening, following minute improvement, or assessing rehabilitation effectiveness, these results highlight the significance of matching the assessment technique to the therapeutic purpose.

There are only limited portions (14.2%) of the physiotherapists that have applied the use of inclinometers as a technique of measuring quadriceps lag. This reflects the practical exposure level, which is very low with physiotherapists and possibly due to fewer training hours or availability of similar devices within their clinical areas.

The physiotherapists had relatively good acquaintance (67.6%) with visual estimation as a tool to quantify quadriceps lag. This suggests that visual estimation is well known and possibly widely utilized in the profession. Although widely utilized, research by authors such as King et al. [16] has indicated that the use of wearable sensors can increase the accuracy of joint angle measurements, offering more trustworthy data compared to subjective visual estimation.

Most (81.8%) of the respondents claimed having personal experience with visual estimation or observation of its application for measurement of quadriceps lag, thus inferring high usage in clinics. Nevertheless, a study by Khalid et al. [17] indicated that objective measures, such as those from wearable technology, could improve treatment outcomes due to their more accurate readings.

There was no information gathered on specific knowledge and utilization of wearable real-time biofeedback devices, smartphone goniometer applications, or photography to assess quadriceps lag. Nonetheless, from the data, it was evident that these tools are less known and utilized among the physiotherapists. According to Porciuncula et al. [18], wearable movement

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eISSN: 2354-0265, ISSN: 2353-6942

sensors are increasingly being used in rehabilitation units, with the ability to enhance real-time feedback during quadriceps strength training.

The survey demonstrated a high degree of agreement between the physiotherapists, with 87% regarding the correct measurement of quadriceps lag as highly relevant in clinical or rehabilitation environments. This underscores the importance of reliable assessments for sound treatment planning and monitoring patient outcomes. The significance of correct measurements has also been established in other studies like that from Balamurugan et al. [19], which identified that post-operative rehabilitation and strength training programs are greatly enhanced by accurate joint angle measurement.

A majority (98.4%) of the participants showed interest in further learning about other ways of assessing quadriceps lag, showing that there is an interest in learning more about measuring tools. Wang et al. [20] discovered that confidence and knowledge about the application of advanced rehabilitation technology among physiotherapists are greatly improved by e-learning programs, with implications for an increased demand for ongoing education concerning measurement instruments.

The respondents to the survey named their most preferred ways of getting information on measuring quadriceps lag. Video tutorials (71.3%) and written guides or articles (65.2%) were the most popular, indicating a strong desire for multimedia. Webinars or online workshops (48%) and workshops or demonstrations in person (37.3%) were also seen as valuable learning resources. These interests correspond with patterns in professional skill-building, as indicated by Arntz et al. [21], who reported that online and distance learning styles are more successful for physiotherapists who wish to enhance their competency.

While the study primarily focused on awareness of measurement methods, it is important to highlight that quadriceps lag is not solely a biomechanical issue but also a neuromuscular issue. In particular, the assessment of muscle characteristics—such as strength,

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eISSN: 2354-0265, ISSN: 2353-6942

tone, trophic condition, and activation patterns—is crucial in clinical evaluation. The VMO, due to its critical role in terminal knee extension and patellar tracking, should be given special attention during rehabilitation. Poor activation of the VMO can result in persistent lag even when structural recovery is achieved. Therefore, comprehensive evaluation tools including manual muscle testing, surface EMG, and visual muscle inspection should complement lag measurements to ensure targeted rehabilitation.

Conclusions

The findings from the survey reveal useful information regarding the awareness and attitudes of physiotherapists toward varying methods of recording quadriceps lag. Whereas goniometry and visual estimation were identified as being usual practices, there is potential for promoting awareness and familiarity with inclinometers, wearable real-time biofeedback equipment, smartphone goniometer applications, and photography. These gaps can be addressed by special educational efforts and thereby promote physiotherapists' knowledge and skill base in precise assessment of quadriceps lag, finally enhancing patient care and outcomes within the realm of rehabilitation.

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Disclosures and acknowledgements

The authors would like to thank all the participants who took part in this study.

The authors declare no conflicts of interest with respect to the research, authorship, and/or publication of this article.

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

eISSN: 2354-0265, ISSN: 2353-6942

The participation in the study was voluntary, and electronic informed consent was obtained before the survey completion. The respondents were assured of the confidentiality and anonymity of their data.

Artificial intelligence (AI) was not used in the creation of the manuscript.

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