Received: 17 October 2023 | Accepted: 11 June 2024

DOI: 10.1002/nau.25529

REVIEW

Neurourology Urodynamics | SUFU Society of Urodynamics, Female Pelvic Medicine & Urogenital Reconstruction | WILEY

Prevalence of levator ani muscle injuries in primiparous women after delivery and their influence on pelvic floor disorders-systematic review

Patrícia Pessoa MSc[1] | **Andreia Carvalho MSc**[1,2] | **Patrícia Mota PhD**[1,2,3]

[1]ESTeSL – Escola Superior de Tecnologia da Saúde, Instituto Politécnico de Lisboa, Lisbon, Portugal

[2]Universidade de Lisboa, Faculdade de Motricidade Humana, CIPER, LBMF, Lisbon, Portugal

[3]H&TRC- Health & Technology Research Center, ESTeSL – Escola Superior de Tecnologia da Saúde, Instituto Politécnico de Lisboa, Lisbon, Portugal

Correspondence
Patrícia Pessoa, MSc, Lisbon School of Health Technology, Polytechnic Institute, Rua Cesário Verde 2790-468, Queijas, Portugal.
Email: ft.patriciapessoa@gmail.com

Abstract

Background: Studies show a significant association between the first vaginal delivery and injuries of the levator ani muscle (LAM), which can cause pelvic floor disorders (PFDs).

Objectives: This study aims to identify the prevalence of short and long-term LAM injuries after vaginal delivery in primiparous women and its influence on PFDs.

Method: A systematic review was conducted according to the PRISMA methodology. The databases used were *Pubmed, Cochrane,* and *PEDro*. The quality assessment of the evidence was carried out using the Critical Appraisal Skills Programme (CASP). Both the selection of studies and their evaluation were done by two researchers and a third reviewer in cases of disagreement.

Results: From the search, 57 articles were gathered, and 19 were included to match the eligibility criteria. The prevalence of avulsion of the LAM was found in association with vaginal delivery between 13% and 28% ≤ 1 year after delivery and between 16% and 29% > 1 year after delivery. Ballooning was detected between 20% and 37% ≤ 1 year, and 33% of women > 1 year after delivery, appearing to be more common when compared to avulsion. Pelvic organ prolapse (POP) was considered the most common disorder associated with injuries of the LAM, and there seems to be some connection with sexual dysfunction.

Conclusion: Avulsion of the LAM and ballooning of the hiatal area have a high prevalence in primiparous women after vaginal delivery and have a strong direct relation to the development of POP.

KEYWORDS

avulsion, ballooning, levator ani muscle, pelvic floor disorders, primiparity, vaginal delivery

1 | INTRODUCTION

Vaginal delivery can potentially impact pelvic floor anatomy and function, which exert a considerable influence on women's quality of life.[1] During labor, the medial parts of the levator ani muscle (LAM), which insert on the ramus of the pubis bone and form a U-shaped sling around the urethra, vagina and rectum, are forced to stretch considerably.[2] Therefore, it is unsurprising that a significant degree of strain may

result in muscle tearing and consequently lead to pelvic floor disorders (PFDs).[3] PFDs, such as urinary incontinence (UI), pelvic organ prolapse (POP), and anal incontinence (AI), are also associated with childbirth and affect numerous women worldwide.[4] Injuries to the LAM may manifest as avulsion, involving the partial or complete detachment of the puborectal muscle from its insertion site into the inferior ramus of the pubis, and ballooning, characterized by an augmented distensibility of the LAM hiatus.[5] According to Dietz et al., the diagnosis of complete avulsion occurs when there is abnormal insertion of the LAM in the three central slices, using ultrasound volumes of the pelvic floor obtained by positioning patients with empty bladders in the dorsal lithotomy position during rest, at maximum contraction, and with the Valsalva maneuver. Type I LAM avulsion is present when the puborectal muscle insertion is partially attached at the pubic level and type II LAM avulsion is defined as complete detachment of the puborectal muscle from its insertion at the pubic level. Excessive distensibility of the levator hiatus ('ballooning') is defined as a levator hiatus area $\geq 25\,cm^2$ on Valsalva.[6,7] These injuries are strongly associated with primiparity and are more common after instrumented vaginal deliveries, namely after forceps deliveries.[8] However, diagnosing this condition can be challenging as there is no consensus on the 'gold standard' imaging modality.[9]

There has been a growing interest in the last decade in innovative methodologies for investigating morphological changes in the pelvic floor, especially in transperineal three-dimensional (3D) and four-dimensional (4D) ultrasonography.[10] Ultrasonography is a handy tool for the anatomical assessment of injuries to the LAM, as it provides access to the axial plane of the muscle, which was previously only possible with magnetic resonance imaging (MRI).[11] It is considerably more cost-effective and, in some aspects, superior to MRI, especially in evaluating dynamic images, crucial for prolapse research studies.[12,13] The 3D/4D ultrasound has enhanced the reliability and accuracy of diagnosing LAM ballooning and avulsion.

While extensive research has focused on severe degrees of perineal trauma, designated as obstetric anal sphincter injuries (OASIS), LAM avulsions have received comparatively less attention. However, these kinds of injuries have long-term morbidities for pelvic floor muscle function. With the rising life expectancy, the PFDs related to LAM can significantly impact urogynaecology services. Understanding the prevalence of LAM avulsions is crucial for public health planning, as it allows early detection and intervention, potentially preventing the escalation of a health issue and reducing the overall impact on individuals and populations.

This study intends to describe the prevalence of injuries of the LAM associated with vaginal delivery in primiparous women in the short and long-term and their impact on the development of PFDs.

2 | MATERIAL AND METHODS

This study is a Systematic Review that was conducted according to the PRISMA protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) with a research question defined following the PECO framework: Population—primiparous women; Exposure—vaginal delivery; Comparator—null; Outcomes—injury of the LAM and/or pelvic floor disorders.

According to the criteria for the submission of the systematic review, the protocol was registered on PROSPERO (Prospective Register of Systematic Reviews) with the registration number ID CRD42022303679.

The inclusion criteria were studies that analyze the prevalence of injuries (avulsion and ballooning) of the LAM after vaginal delivery in primiparous women (1); studies that LAM lesion was diagnosed by 3D/4D transperineal ultrasound (2); studies that use the diagnostic criteria for avulsion and ballooning, described by Dietz (3); studies investigating PFDs associated with injury of the LAM (4); and articles written in Portuguese, Spanish and English language (5). Review studies (1) and those that did not use number and type of birth to organize their results (2) were considered exclusion criteria.

For this study, the prevalence of LAM injury was divided between values ≤ 1 year and > 1 year after delivery. Also, this systematic review will not prioritize magnetic resonance imaging, as a larger body of research utilizes ultrasound, given its cost-effectiveness and widespread accessibility. Furthermore, several articles have recently shown that ultrasound is at least equally effective in diagnosing this type of trauma.[14]

A search was carried out in Pubmed, Cochrane, and PEDro electronic databases, based on the following research question: "What is the prevalence of injuries of the levator ani muscle after vaginal delivery in primiparous women and their influence on the development of pelvic floor disorders?". To this end, the following research equation was constructed: (((primiparity) OR (primiparous)) AND ((“delivery”) OR (birth) OR (childbirth) OR (postpartum)) AND ((“levator ani muscle”) OR (puborectalis) OR (iliococcygeal) OR (pubococcygeal)) AND ((“pelvic floor trauma”) OR (“ani levator avulsion”) OR (“pelvic floor disorders”) OR (“pelvic floor dysfunctions”) OR (“pelvic floor functions”))). There was no restriction regarding the

publication dates of the articles. The survey was conducted between October 2021 and November 2021.

Two blinded reviewers selected the studies through an analysis of the titles and abstracts of each article, and the existing conflicts were resolved by a third reviewer. Subsequently, for all studies covered, the full text was reviewed to determine eligibility. The inclusion or exclusion of articles was defined according to pre-established eligibility criteria, which were carefully followed.

The methodological quality of the studies included was assessed using the Critical Appraisal Skills Program (CASP) checklists, which allows for the identification of potential biases in the assessed studies, asking reviewers to answer specific questions through "yes", "no" or "can't tell". The CASP checklist was used for the Cohort studies (12 questions) and the Case-Control studies (11 questions). "Yes" answers added 1 point, while "no" or "can't tell" answers did not add up any points. Scoring was converted into percentages. The studies were classified as: "highly clinically applicable" with a score of 67%–100%, "potentially clinically applicable" with 34%–66%, and "clinically less applicable" with a score of 0–66 with 33%. In this case, two independent researchers also evaluated the articles, and a third resolved the conflicts.

3 | RESULTS

The searches lead to a total of 57 articles. After eliminating duplicate articles, 56 were evaluated for their title and abstracts, and 29 were selected for full reading. Of the 29 potentially relevant articles, 10 did not meet the inclusion criteria. Finally, 19 studies were included in this systematic review (14 cohort studies, 4 case-control studies, and 1 cross-sectional study). Figure 1 shows in detail the selection process of the included studies. All selected studies were methodologically evaluated by CASP and the results for each item are shown in Tables 1 and 2.

The 19 studies included a total population of 5221 primiparous women, with an average age of 31.1 ± 4.8 years old (mean ± standard deviation). The studies included in this review were conducted in 10 different countries. Most of the included studies assessed the

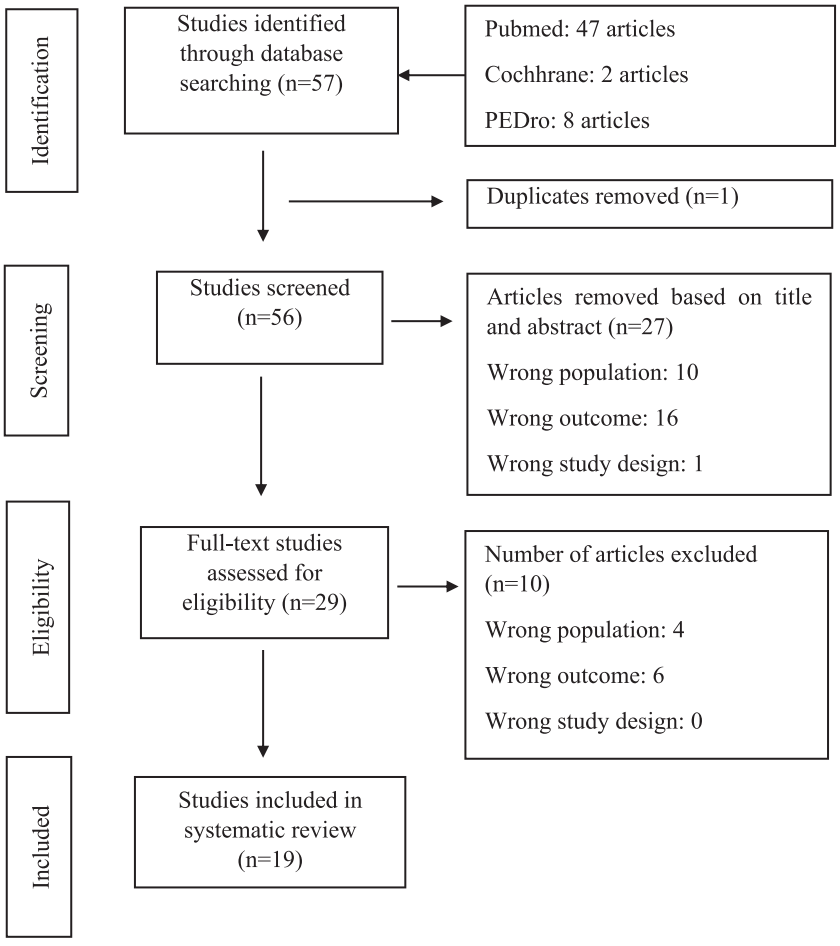

FIGURE 1 Flow diagram of the research conducted.

TABLE 1 Methodological quality assessment with CASP cohort study checklist.

	1	2	3	4	5a	5b	6a	6b	7	8	9	10	11	12	Score	%
Dietz et al.[17]	Y	Y	Y	Y	Y	Y	CT	Y	Y	Y	Y	Y	Y	Y	13	93
Cassadó et al.[11]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	14	100
Sainz et al.[22]	Y	Y	Y	CT	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	13	93
Mejido et al.[27]	Y	Y	Y	Y	Y	Y	Y	CT	Y	Y	Y	Y	CT	CT	11	79
Mejido & Sainz[18]	Y	CT	Y	Y	Y	Y	CT	Y	CT	CT	CT	Y	Y	CT	8	57
Ubankova et al.[1]	Y	Y	Y	CT	Y	Y	Y	Y	Y	CT	CT	Y	Y	CT	10	71
Mejido et al.[21]	Y	CT	CT	CT	Y	Y	Y	CT	Y	CT	CT	CT	CT	CT	5	36
Valsky et al.[16]	Y	CT	CT	Y	Y	Y	CT	Y	Y	CT	CT	CT	Y	CT	7	50
Durnea et al.[10]	Y	Y	Y	CT	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	13	93
Van Delft et al.[28]	Y	Y	Y	Y	Y	Y	Y	CT	Y	Y	Y	Y	Y	Y	13	93
Chan et al.[26]	Y	CT	CT	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12	86
Durnea et al.[25]	Y	Y	Y	CT	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	13	93
Cassadó et al.[29]	Y	Y	CT	Y	Y	Y	CT	Y	Y	CT	Y	Y	CT	Y	10	71
Araújo et al.[30]	Y	CT	CT	Y	CT	CT	CT	CT	Y	CT	N	CT	CT	CT	3	21
Dietz et al.[23]	Y	Y	Y	CT	Y	Y	CT	CT	Y	CT	CT	Y	CT	CT	7	50

Abbreviations: %, score converted to percentage; CASP, Critical Appraisal Skills Programme; CT, Can't Tell; N, no; Y, yes. Item 1, clearly focused issue; Item 2, adequate recruitment method; Item 3, adequate measurement of exposure; Item 4, adequate measurement of outcome; Item 5a, identification of all of the important confounding factors; Item 5b, adequate study design accounting for the confounding factors; Item 6a, follow-up of subjects complete enough; Item 6b, follow-up of subjects long enough; Item 7, results of study; Item 8, accuracy of results; Item 9, truth of the results; Item 10, application of the results to the population of a local area; Item 11, agreement with other available evidence; Item 12, implications of the study for practice.

TABLE 2 Methodological quality assessment with CASP case–control study checklist.

	1	2	3	4	5	6a	6b	7	8	9	10	11	Score	%
Valsky et al.[15]	Y	Y	Y	CT	CT	Y	CT	Y	Y	Y	Y	CT	8	67
Michalec et al.[19]	Y	Y	CT	N	Y	CT	Y	CT	Y	CT	Y	Y	7	58
Laterza et al.[24]	Y	Y	Y	Y	CT	Y	Y	Y	CT	Y	Y	Y	10	83
Cassadó et al.[20]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12	100

Abbreviations: %, score converted to percentage; CASP, Critical Appraisal Skills Programme; CT, can't tell; N, no; Y, yes. Item 1, clearly focused issue; Item 2, appropriate methodology; Item 3, adequate recruitment method; Item 4, adequate selection of controls; Item 5, adequate measurement of exposure; Item 6a, equal treatment of the groups; Item 6b, adequate study design accounting for the confounding factors; 7, treatment effect; Item 8, accurate estimation of treatment effect; Item 9, truth of the results; Item 10, application of the results to the population of a local área; Item 11, agreement with other available evidence.

presence of LAM injury in the first 12 months after delivery, except for the studies carried out by Valsky et al.,[15,16] Durnea et al.,[10] and Dietz et al.,[17] who carried out assessments at 18 months, 21, months, 21 months, and 33 years after the first delivery, respectively.

A prevalence of avulsion between 13% and 28% was found during the ≤ 1 year after delivery, and a prevalence between 16% and 29% in studies with assessments >1 year. For the results of this review, the prevalence of avulsion was not specified according to the type of avulsion because not all studies did it. Furthermore, no differentiation was made between instrumented and non-instrumented vaginal delivery. Nonetheless, one of the main risk factors for LAM avulsion identified in many studies in this review was instrumental delivery.

Five studies were more specific in the description of the characteristics of the avulsion, classifying them as bilateral, unilateral, right-side, or left-side avulsions. Mejido and Sainz[18] verified 54% unilateral avulsions and 46% bilateral avulsions, of which 54.9% occurred on the right and 45.1% on the left side; in the study by Urbankova et al.,[1] 18.1% of the sample presented

unilateral avulsion and 9% bilateral avulsion, with a greater predominance on the left side (63%); Michalec et al.[19] concluded 10% unilateral and 2% bilateral incidence; in the study by Cassadó et al.,[20] 20% were bilateral avulsions, with a predominance of lesions on the right-side; finally, Mejido et al.[21] found a higher prevalence of unilateral avulsions.

Ballooning was also studied by some researchers, particularly Sainz et al.,[22] who found it in 20% of women; Urbankova et al.[1] in 31.3%; Durnea et al.[10] in 33%; and Dietz et al.[23] found an occurrence of 37%.

In the 19 included studies, only six described PFDs. According to Urbankova et al.[1] UI was 1.6 times more likely in women with LAM avulsion, as was the development of POP II, which involves prolapse within 1 cm above or below the hymen according to Pelvic Organ Prolapse Quantification (POP-Q); Laterza et al.[24] reinforce the association of urinary symptoms with LAM avulsion, as well as with the development of POP I, which indicates prolapses more than 1 cm above the hymen (according to POP-Q); Durnea et al.[25] verified the presence of cystocele (90%), uterine prolapse (89%) and rectocele (70%), for which the most persistent and significant risk factor was a trauma of the LAM; finally, Chan et al.[26] reported that avulsion was associated with POP symptoms at 8 weeks after delivery, but not at 12 months after delivery. The study by Mejido et al.[27] concluded that decreased sexual desire, lubrication, satisfaction, and orgasm were experienced more often by women with avulsion compared to those without avulsion.

All the details of the included studies, namely the main author and year, sample, assessment tools, the moment of the assessments, and results are shown in Table 3.

4 | DISCUSSION

The rate of prevalence of LAM avulsion during the first 12 months after vaginal delivery in primiparous women ranged from 13% to 28% in included studies. It is crucial to consider that one of the causes for the variability of prevalence may be that the management of childbearing and obstetric practices varies significantly from country to country.[11] Another possible reason for the difference in prevalence could be the different moments of the assessments of LAM avulsion. Some investigators propose that the diagnosis of LAM injuries should be only made at least 1 year after delivery, given that the expected changes in the pelvic floor associated with pregnancy may persist for up to 6 months, or more, after delivery.[10]

Only four studies performed assessments 12 months after delivery, finding a LAM avulsion prevalence of 16%–29%. Of these studies, Dietz et al.[17] was the only one that researched and retrieved results 30 years after the first delivery, obtaining a prevalence of 23% of women with avulsion. According to the evidence, healing of LAM avulsion was reported to happen between 6 months to 3 years after delivery and depends on the type of avulsion, where type II avulsion has less regeneration capacity than type I avulsion.[31] However, there is limited information on the long-term prevalence of LAM avulsion after first delivery. More studies with representative samples are necessary to investigate the long-term prevalence of LAM avulsion after childbirth.

Another interesting conclusion about prevalence is the higher percentage of avulsions of LAM on the right side compared to the left side. Kimmich et al.[32] who studied, in particular, the association between fetal, maternal, and obstetric factors and the side of the body affected when avulsion occurs, concluded that no significant factor could be associated with the laterality of the trauma. However, they hypothesize the influence of the fetal position on this.

Instrumental delivery was mentioned by many studies included in this review as one of the main risk factors for avulsion. Cassadó et al.[11] went further and studied the prevalence of LAM injuries in different methods of vaginal delivery, from which they concluded that, with spontaneous delivery taken as reference, forceps delivery increases the risk of avulsion by 12.31 times and vacuum-assisted delivery by 4.78 times. Multiparity has also been the object of study by researchers. There appears to be no difference between the prevalence of LAM injuries after the first delivery and after subsequent deliveries (although the degree of the injury may worsen), showing that most avulsions may be caused by the first vaginal delivery.[17]

Ballooning was another type of injury considered in this study. It is important to note that the criteria for the diagnostic of abnormal distensibility of the levator hiatal are not as standardized as those for avulsion, which is why it was decided to consider only the results of studies that used the criterion of a hiatal area of ≥25 cm^2 on Valsalva.[6] Similar to the conclusions drawn for the risk of avulsion, the risk of overdistension increases after forceps delivery compared with vacuum-assisted delivery. According to some studies in the review, LAM avulsion appears less likely than ballooning.

This systematic review demonstrates a strong relation between LAM injury and the development of POP, with a higher prevalence of uterine prolapse and cystocele in primiparous women,[1,10,24,25] with stage I and II,[1] proving that LAM plays an important role in support of the pelvic

TABLE 3 Details of studies included in the review.

Reference of study	Sample (primiparous women with vaginal delivery)	Assessment tools	Follow-up (after delivery)	Prevalence of LAM injuries	LAM injuries related PFDs
Dietz et al.[17]	156	4D Ultrasound	Average of 33 years	Avulsion: 23%	_
Cassadó et al.[11]	303	3D/4D Ultrasound	12 months	Avulsion: 19%	_
Sainz et al.[22]	250	3D/4D Ultrasound	6 months	Ballooning: 20%	_
Mejido & Sainz[18]	176	4D Ultrasound	12 months	Avulsion: 20%	_
Mejido et al.[27]	100	FSFI	6 months	_	Decreased sexual desire, lubrication, satisfaction, and orgasm in women with avulsion.
Urbankova et al.[1]	987	3D/4D Ultrasound ICIQ-SF PISQ12 Oxford scale	12 months	Avulsion: 27% Ballooning: 31%	Avulsion and ballooning associated with UI and POP II
Valsky et al.[15]	464	3D Ultrasound	18 months	Avulsion: 16%	_
Mejido et al.[21]	71	3D/4D Ultrasound	6 months	Avulsion: 13%	_
Michalec et al.[19]	184	3D Ultrasound	6 months	Avulsion: 11%	_
Durnea et al.[10]	202	3D Ultrasound	21 months	Ballooning: 33% Avulsion: 29%	Uterine prolapse: 63% Cystocele: 42% Rectocele: 23%
Valsky et al.[16]	87	3D Ultrasound	21 months	LAM lesion: 22%	_
Van Delft et al.[28]	191	4D Ultrasound	3 months	Avulsion: 21%	_
Laterza et al.[24]	40	3D Ultrasound	12 months	_	UI and POP I associated with LAM injury.
Chan et al.[26]	328	3D Ultrasound PFDI PFIQ POP-Q POPDI UDI	12 months	Avulsion: 19%	LAM injury was associated with prolapse symptoms. No association of SUI, urgency urinary incontinence (UUI), Mixed Urinary Incontinence (MUI) or FI
Durnea et al.[25]	202	4D Ultrasound	12 months	_	Cystocele: 90% Uterine prolapse: 89% Rectocele: 70%
Cassadó et al.[29]	914	4D Ultrasound	12 months	Avulsion: 13%	_
Araújo et al.[30]	35	3D Ultrasound	24h-48h	Avulsion: 28%	_
Dietz et al.[23]	351	4D Ultrasound	6 months	Avulsion: 13% Ballooning: 37%	_
Cassadó et al.[20]	180	4D Ultrasound	4 months	Avulsion: 25%	_

Abbreviations: CG, control group; EG, experimental group; G1, group 1; G2, group 2; G3, group 3.

organs. The increase of the hiatal area reinforces a relation between the injury of the LAM and the development of POP. The study by Mejido et al.[27] was the only study included in this review that explored sexual dysfunction in relation to avulsion, showing a decrease in sexual desire, lubrication, satisfaction, and orgasm in women with avulsion, possibly due to a weakening of the pelvic floor.

The main strength of our systematic review lies in the methodology we followed. We believe that the inclusion criteria specified for this review make it relevant, namely the choice of ultrasonography for diagnosing LAM lesions and the uniqueness of the criteria defined by Dietz. Furthermore, this review not only demonstrates the prevalence of LAM injuries but also the association with pelvic floor dysfunctions. However, some limitations to

our review might have introduced bias into our findings. One limitation is the variability in the timing of ultrasound examinations across the included studies, making direct comparisons challenging. The lack of standardized timing for these assessments may introduce variability in detecting and reporting LAM injuries. Another limitation is the scarcity of studies providing long-term prevalence results for LAM lesions. The absence of sufficient data on the enduring prevalence of LAM injuries hinders a comprehensive understanding of the persistence and potential consequences of such injuries over time. This emphasizes the need for future studies to address this gap and conduct analyses beyond immediate postpartum periods, enhancing the robustness and applicability of findings in guiding therapeutic interventions.

LAM injuries and PFDs are prevalent in the period after delivery and can, at a later stage, lead to consequences that considerably reduce women's quality of life. These women must be informed that they can prevent dysfunctions through follow-up before delivery and be followed up after delivery. In this way, it is crucial to raise the awareness of health professionals for the early referral of pregnant women to physiotherapists specialized in women's health. Physiotherapists specializing in women's health develop clinical reasoning adapted to the obstetric history of each patient and master a set of specific therapeutic interventions. Physiotherapy should be the frontline conservative management of pelvic floor disorders.[33]

5 | CONCLUSIONS

In this study, it is concluded that there is a high prevalence of LAM injury in primiparous women after vaginal delivery. Although LAM avulsion produces more severe symptoms, both avulsion and ballooning lead to a weakening of the pelvic floor and the development of disorders, with a higher prevalence of POP. It is essential to act to prevent and treat these dysfunctions to improve women's quality of life.

AUTHOR CONTRIBUTIONS

Patrícia Pessoa: Conception; organization; execution; design; execution; review and critique; writing of the first draft; review and critique. **Andreia Carvalho**: Conception; organization; design; execution; review and critique. **Patrícia Mota:** Conception; organization; design; execution; review and critique.

ACKNOWLEDGMENTS

No specific funding was received for this work.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ETHICS STATEMENT

Ethics of approval statement, patient consent statement, and permission to reproduce material from other sources were not necessary for this study.

REGISTER NUMBER

According to the criteria for the submission of the systematic review, the protocol was registered on PROSPERO (Prospective Register of Systematic Reviews) with the registration number ID CRD42022303679.

ORCID

Patrícia Pessoa https://orcid.org/0000-0002-2748-6595
Andreia Carvalho https://orcid.org/0000-0003-4469-2021
Patrícia Mota https://orcid.org/0000-0003-2120-7783

REFERENCES

1. Urbankova I, Grohregin K, Hanacek J, et al. The effect of the first vaginal birth on pelvic floor anatomy and dysfunction. *Int Urogynecol J*. 2019;30(10):1689-1696.
2. Siafarikas F, Stær-Jensen J, Hilde G, Bø K, Ellström Engh M. The levator ani muscle during pregnancy and major levator ani muscle defects diagnosed postpartum: a three- and four-dimensional transperineal ultrasound study. BJOG An. *Int J Obstet Gynaecol*. 2015;122(8):1083-1091.
3. Lawson S, Sacks A. Pelvic floor physical therapy and women's health promotion. *J Midwifery Women's Heal*. 2018;63(4):410-417.
4. Abrams P, Cardozo L, Wagg A, Wein A Epidemiology of urinary (UI) and faecal (FI) incontinence and pelvic organ prolapse (POP). 2017:256-312. http://www.ics.org/Publications/ICI_3/v1.pdf/chap5.pdf
5. Caudwell-Hall J, Kamisan Atan I, Guzman Rojas R, Langer S, Shek KL, Dietz HP. Atraumatic normal vaginal delivery: how many women get what they want? *Am J Obstet Gynecol*. 2018;219(4) 379.e1-379.e8.
6. Dietz HP, Shek C, De Leon J, Steensma AB. Ballooning of the levator hiatus. *Ultrasound Obstet Gynecol*. 2008;31(6):676-680.
7. Dietz HP, Bernardo MJ, Kirby A, Shek KL. Minimal criteria for the diagnosis of avulsion of the puborectalis muscle by tomographic ultrasound. *Int Urogynecol J*. 2011;22(6):699-704.
8. Wu E, Kuehl TJ, Gendron JM, White W, Yandell PM. Pelvic floor changes in the first term pregnancy and postpartum period. *Int Urogynecol J*. 2020;32(7):1897-1905.
9. Doxford-hook E, Downey C, Gibson J, Marsh F. A review of levator ani avulsion after childbirth : Incidence, imaging and management. *Midwifery*. 2022;115:103494.

10. Durnea CM, O'Reilly BA, Khashan AS, et al. Status of the pelvic floor in young primiparous women. *Ultrasound Obstet Gynecol*. 2015;46(3):356-362.
11. Cassadó J, Simó M, Rodríguez N, et al. Prevalence of levator ani avulsion in a multicenter study (PAMELA study). *Arch Gynecol Obstet*. 2020;302(1):273-280.
12. Brækken IH, Majida M, Ellstrøm-Engh M, Dietz HP, Umek W, Bø K. Test-Retest and intra-observer repeatability of two-, three- and four-dimensional perineal ultrasound of pelvic floor muscle anatomy and function. *Int Urogynecol J*. 2008;19(2):227-235.
13. Dietz HP. Ultrasound imaging of the pelvic floor. Part II: three-dimensional or volume imaging. *Ultrasound Obstet Gynecol*. 2004;23(6):615-625.
14. Dietz HP. Pelvic floor trauma in childbirth. Aust New Zeal. *J Obstet Gynaecol*. 2013;53(3):220-230.
15. Valsky DV, Cohen SM, Lipschuetz M, et al. Third- or fourth-degree intrapartum anal sphincter tears are associated with levator ani avulsion in primiparas. *J Ultrasound Med*. 2016;35(4):709-715.
16. Valsky DV, Lipschuetz M, Cohen SM, et al. Persistence of levator ani sonographic defect detected by three-dimensional transperineal sonography in primiparous women. *Ultrasound Obstet Gynecol*. 2015;46(6):724-729.
17. Dietz HP, Walsh C, Subramaniam N, Friedman T. Levator avulsion and vaginal parity: do subsequent vaginal births matter? *Int Urogynecol J*. 2020;31(11):2311-2315.
18. García-Mejido JA, Sainz JA. Type of levator ani muscle avulsion as predictor for the disappearance of avulsion. *Neurourol Urodyn*. 2020;39(8):2293-2300.
19. Michalec I, Simetka O, Navratilova M, et al. Vacuum-assisted vaginal delivery and levator ani avulsion in primiparous women. *J Matern Neonatal Med*. 2016;29(16):2715-2718.
20. Cassadó Garriga J, Pessarrodona Isern A, Espuna Pons M, et al. Four-dimensional sonographic evaluation of avulsion of the levator ani according to delivery mode. *Ultrasound Obstet Gynecol*. 2011;38(6):701-706.
21. Garcia-Mejido JA, Gutierrez-Palomino L, Borrero C, Valdivieso P, Fernandez-Palacin A, Sainz-Bueno JA. Factors that influence the development of avulsion of the levator ani muscle in eutocic deliveries: 3–4D transperineal ultrasound study. *J Matern Neonatal Med*. 2016;29(19):3183-3186.
22. Sainz JA, González-Diaz E, Martínez AM, et al. Prevalence of levator hiatal overdistension after vacuum and forceps deliveries. *Neurourol Urodyn*. 2020;39(2):841-846.
23. Dietz HP, Shek KL, Chantarasorn V, Langer SEM. Do women notice the effect of childbirth-related pelvic floor trauma? Aust New Zeal. *J Obstet Gynaecol*. 2012;52(3):277-281.
24. Laterza RM, Schrutka L, Umek W, Albrich S, Koelbl H. Pelvic floor dysfunction after levator trauma 1-year postpartum: a prospective case–control study. *Int Urogynecol J*. 2015;26(1):41-47.
25. Durnea CM, Khashan AS, Kenny LC, Durnea UA, Smyth MM, O'Reilly BA. Prevalence, etiology and risk factors of pelvic organ prolapse in premenopausal primiparous women. *Int Urogynecol J*. 2014;25(11):1463-1470.
26. Chan SSC, Cheung RYK, Yiu KW, Lee LL, Chung TKH. Effect of levator ani muscle injury on primiparous women during the first year after childbirth. *Int Urogynecol J*. 2014;25(10):1381-1388.
27. García-Mejido JA, Idoia-Valero I, Aguilar-Gálvez IM, Borrero González C, Fernández-Palacín A, Sainz JA. Association between sexual dysfunction and avulsion of the levator ani muscle after instrumental vaginal delivery. *Acta Obstet Gynecol Scand*. 2020;99(9):1246-1252.
28. Van Delft K, Thakar R, Sultan AH, Schwertner-Tiepelmann N, Kluivers K. Levator ani muscle avulsion during childbirth: A risk prediction model. BJOG An. *Int J Obstet Gynaecol*. 2014;121(9):1155-1163.
29. Cassadó J, Pessarrodona A, Rodriguez-Carballeira M, et al. Does episiotomy protect against injury of the levator ani muscle in normal vaginal delivery? *Neurourol Urodyn*. 2014;33:1212-1216.
30. Araujo Júnior E, Freitas RCM, de Di Bella ZIK, de J, et al. Assessment of pelvic floor by three-dimensional-ultrasound in primiparous women according to delivery mode: initial experience from a single reference service in Brazil. Rev Bras Ginecol e. *Obs*. 2013;35(3):117-122.
31. Van Gruting IMA, van Delft KWM, Sultan AH, Thakar R. Natural history of levator ani muscle avulsion 4 years following childbirth. *Ultrasound Obstet Gynecol*. 2021;58(2):309-317.
32. Kimmich N, Birri J, Zimmermann R, Kreft M. Association between the side of levator Ani muscle trauma and fetal position at birth - a prospective observational study. *Z Geburtshilfe Neonatol*. 2021;225(2):134-139.
33. Wallace SL, Miller LD, Mishra K. Pelvic floor physical therapy in the treatment of pelvic floor dysfunction in women. *Curr Opin Obstet Gynecol*. 2019;31(6):485-493.

How to cite this article: Pessoa P, Carvalho A, Mota P. Prevalence of levator ani muscle injuries in primiparous women after delivery and their influence on pelvic floor disorders-systematic review. *Neurourol Urodyn*. 2024;43:1962-1969. doi:10.1002/nau.25529