Differences in Muscle Activation While Walking on Individuals with Chronic Low Back Pain: A Systemic Review and Meta-analysis

Alifa Akbar[1(✉)], Suryo Saputra Perdana[1], and Amalia Nur Azizah[2]

[1] Faculty of Medicine, Universitas Muhammadiyah Surakarta, Surakarta, Indonesia
J120190143@student.ac.id

[2] Faculty of Medicine, Physiotherapy Department, National Paralympic Committee of Indonesia, Surakarta, Indonesia

Abstract. Background: Understanding variations in muscle movement in LBP patients is crucial to help avoid and improve treatment for LBP patients. Low back pain, or LBP, is indicated by the onset of discomfort in the lower back area. If it is not treated effectively, LBP can interfere with everyday activities. Method: To identify variations in muscle movement, searches were made in all 4 databases (PubMed, Scopus, Google Scholar, and Science Direct). These searches were followed by a systematic review and meta-analysis. Result: In the LBP group, a substantial increase in paraspinal muscle movement was found (SMD: 0.83, 95% Cl: 0.37 to 1.3, effect $p = 0.0004$). Conclusion: This research found that the LBP group's muscle activation when walking differs significantly from that of the control group. Incorporating the appropriate treatment for each patient's condition can be made easier for physiotherapists because substantial research demonstrates variances in muscle movement in patients suffering from LBP. By observing the altered pattern of muscle movement in LBP patients, this study is highly beneficial in the clinical setting to investigate the effects of various rehabilitation programs.

Keywords: LBP · Muscle Activity · Walking · Trunk

1 Introduction

The most frequent health issue that prevents people from engaging in certain activities, low back pain (LBP), is indicated by discomfort that radiates from the lower border of the ribs to the buttocks (and may occur with or without pain in the legs) [1–3]. According to American studies, up to 84% of people experience LBP at some point in their lifetime, making it the fifth most prevalent reason for doctor visits [3–5]. Risk factors for radicular pain, disc degeneration, myofascial pain, sacroiliac joint pain, nociplastic pain, facet arthropathy, and spondyloarthropathies are numerous and contribute to the pathophysiology of LBP [6–8].

The duration of the pain is used to classify different types of low back pain: (1) acute LBP < (4 weeks), (2) subacute LBP (4 weeks–3 months), and (3) chronic LBP > (3 months) [1, 3, 9]. Pain is typically associated with an impact on limitations in daily

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activities, one of which is walking [10–12]. Chronic low back pain sufferers will alter spatiotemporal gait factors such as stride length, stride speed, kinematic features, kinetic characteristics, and electromyographic (EMG) characteristics to focus on the amplitude and timing of muscle activation [13–15]. Based on differences in EMG activity between people with and without LBP, it is thought that EMG can be used as an accurate measurement tool in people with LBP when compared to healthy people [13, 16, 17].

The most frequent functional action is walking, which is performed repeatedly. When moving both legs in a walking motion, the trunk and lumbar spine play a crucial role in stabilization and control [12, 18, 19]. Walking speed is typically adjusted by the alignment of the pelvis and upper back on the axial section of the body, but LBP patients exhibit a more pronounced pattern of movement [13, 20, 21].

In an effort to help prevent and improve treatment in LBP individuals, knowing the structural changes in muscles in LBP individuals is important [8, 22, 23]. Recent studies have identified no significant differences in the amplitude of gluteus medius muscle movement during walking [24–26]. Meanwhile, other studies found an increase in back muscle movement in LBP individuals [17, 27, 28]. Others discovered that when healthy people walk while fatigued, there is a relative increase in the activity of the muscles in the erector spinae, rectus abdominis, vastus medialis, vastus lateralis and lumbar erector spinae, as well as a slowing of movement in a trial to increase trunk stiffness and stabilization [29–31].

High-pain LBP sufferers typically stabilize their spine during repetitive flexion-extension motions [27, 32, 33]. It has been identified that individuals with LBP who repeatedly lift weights, take or place objects under them, and sit down show different patterns of muscle movement [27, 30, 34]. It is not yet known for sure whether there are variations in muscle movement when performing other functional movements. As a result, the goal of this research was to identify variations in muscle movement during walking in people with LBP disorders in comparison to healthy people.

2 Methods

2.1 *Research* Design

To integrate previous research and statistically assess current data, the research approach used is a systematic review and meta-analysis based on the Preferred Reporting Items for Systematic Review and Meta- Analysis (PRISMA).

2.2 Search Strategy

Data used in this research were derived from several databases, such as PubMed, Scopus, Google Scholar, and Science Direct, without any time limit for publication. The search used the word combination gait OR walking AND SEMG OR surface electromyography OR EMG AND low back pain OR back pain AND muscle OR muscle activation. This search was done in October 2022. If there were any duplicate studies, they were all chosen, and the remaining data were then subjected to a full text screening after an initial screening of the titles and abstracts that met the inclusion criteria (Figure 1).

2.3 Inclusion and Exclusion Criteria

Prior to review, exclusion and inclusion criteria are established for the studies that will be considered. The following are some of the inclusion criteria that were applied: (1) original paper available in English, (2) case control, cross-sectional, and prospective cohort study types, (3) paper comparing variations in walking styles between people with chronic or acute LBP and healthy people as controls, and (4) results of measuring muscle movement using EMG in the lower lumbar paraspinal and abdominal regions. The study was excluded if it did not meet the inclusion criteria, such as: (1) the paper was in the form conference abstract, case report, dissertation or review article, (2) in the LBP group there were other musculoskeletal diagnoses.

2.4 Quality Assessment

A 16-criteria checklist from previous studies was utilized to assess the quality and bias risk of the included studies (Table 1) [35, 36]. Each criterion that fit the study was given a positive score. The total study quality score was calculated by adding up all the positive scores for each criterion, then dividing by the results of each cross-sectional study score: 8, case control: 12, cohort: 9. Study designs that have values above 50% indicate high quality reporting (Table 2).

2.5 Data Extraction and Data Analysis

Data extraction was carried out by entering the SD and mean of each study that met the criteria utilizing the Review Manager Version 5.4.1 software to determine differences in muscle movement. The extracted data are as follows: author, year of publication, total population, gender, LBP symptoms, and outcome (Table 3).

3 Result

From the results of the initial search conducted on the four databases, 410 studies were identified. There are eight studies that measure muscle movement in the LBP and healthy control groups after going through several stages such as removing duplication, screening titles and abstracts, and screening full text.

3.1 Study Characteristics

The different designs used in this study include:

(1) case-control, (2) cross-sectional, and (3) cohort study. The duration of LBP experienced by patients also varied, based on data collected, the duration of LBP was at least more than 3 weeks (Table 2).

3.2 Systematic Review

Results of a systematic review showed different categories of trunk and abdominal muscle movement in the LBP group in comparison to healthy controls.

Table 1. Checklist for evaluating case-control, cross-sectional, and prospective cohort study designs' methodological quality

Domain and item member	Description	CS	CC	PC
Study objective				
1	Positive, if the study has a clearly defined objective	+	+	+
Study Population				
2	Positive, if the main features of the study population are described (sampling frame and distribution of the population according to age and sex)	+	+	+
3	Positive, if cases and controls are drawn from the same population and a clear definition of cases and controls is given and if subjects with the disease/symptom in the past 3 months are excluded from the control group		+	
4	Positive, if the participation rate is at least 80% or if the participation rate is 60%_80% and the non-response is not selective (data shown)	+	+	+
5	Positive, if the participation rate at main moment of follow-up is at least 80% or if the non-response is not selective (data shown) Measurements			+
Measurement				
6	Positive, if data on history of the disease/symptom is collected and included in the statistical analysis	+	+	+
7	Positive, if the outcome is measured in an identical manner among cases and controls		+	
8	Positive, if the outcome assessment is blinded with respect to disease status	+	+	
9	Positive, if the outcome is assessed at a time before the occurrence of the disease/symptom		+	

(*continued*)

Table 1. (*continued*)

Domain and item member	Description	CS	CC	PC
Assesment of the outcome				
10	Positive, if the time-period on which the assessment of disease/symptom was based was at least 1 year			+
11	Method for assessing injury status: physical examination blinded to exposure status (+); self-reported: specific questions relating to symptoms/disease/use of manikin (+), single question (_)	+	+	+
12	Positive, if incident cases were included (prospective enrollment) Analysis and data presentation		+	
Analysis and data presentation				
13	Positive, if the measures of association or group comparisons estimated were presented including confidence intervals	+	+	+
14	Positive, if the analysis is controlled for confounding or effect modification: individual factors	+	+	+
15	Positive, if the analysis is controlled for confounding or effect modification: other factors	+	+	+
16	Positive, if the number of cases in the final multivariate model was at least 10 times the number of independent variables in the analysis	+	+	+
Total possible score (sum of item 3-16)		8	12	9
Abbreviations: CC = case-control; CS = cross sectional; PC = prospective cohort.				

3.2.1 Trunk Muscle Movement

When walking, the average activity of the erector spinae will experience a significant increase in the LBP group. Farahpour et al., (2018) reported that the EMG signal from

the erector spinae at L3 was lower in the control group [37]. Hulst et al., (2010) and Hanada et al., (2011) also stated that movement in the lumbar erector spinae muscles tends to be higher in the LBP group [38, 39]. 3 studies also reported increased amplitude of the LES (lumbar erector spinae) muscles [20, 40, 41] during the ipsilateral swing phase at L2 and L4 [20]. However, Arjunan et al., (2018) reported that there was a major difference in erector spinae muscle movement when running, but found no significant difference when walking [42].

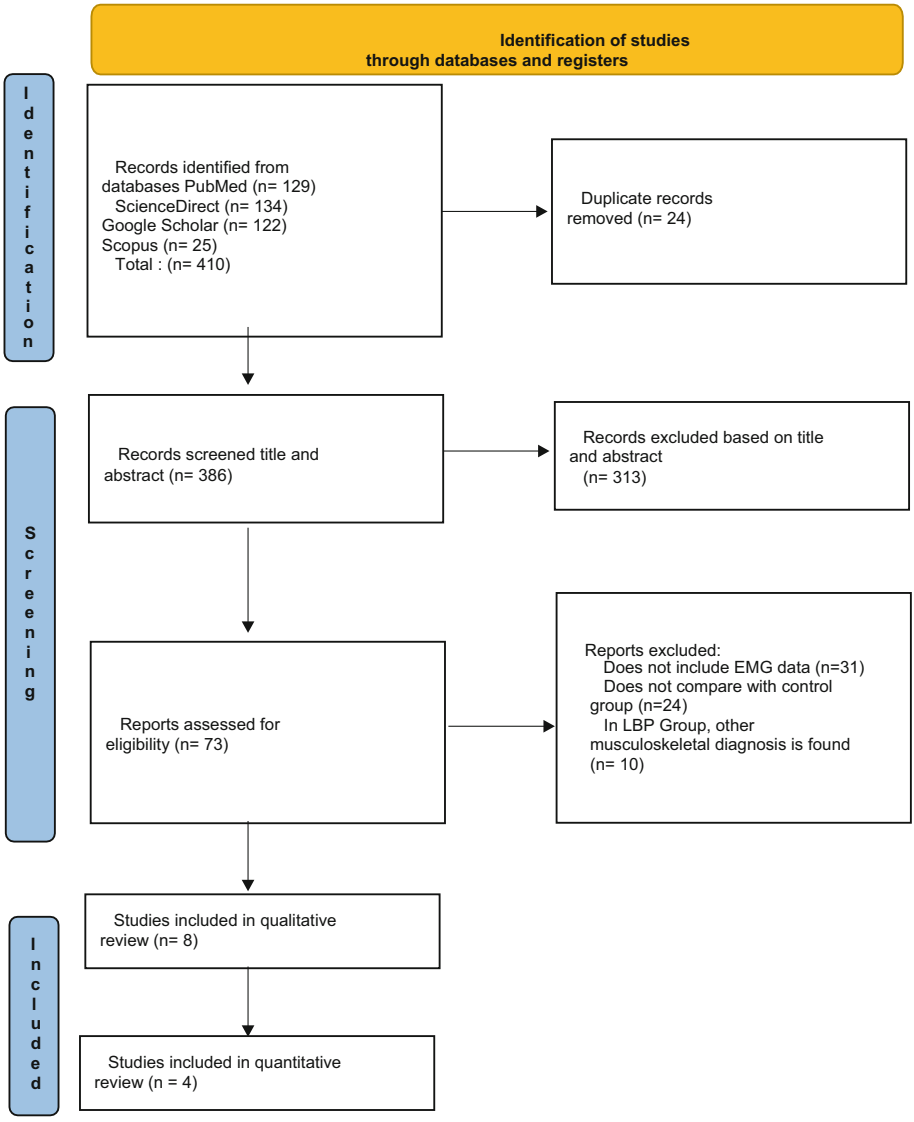

Fig. 1. Diagram PRISMA

Table 2. Characteristic of included studies

AUTHOR (YEAR)	STUDY DESIGN	SAMPLE	LBP SYMPTOM	MUSCLE	OUTCOME	RESULT
Kim et al .,(2017)	Case Control	LBP (n = 30) Control (n = 15)	Non-specific LBP of over 7 weeks and pain above the inferior gluteal folds and below the costal margin	External Obliques, Rectus Abdominis, and Internal Obliques	There was no substantial difference in muscle movement in the Rectus Abdominisand External Obliques; Internal obliqueswere lower (P=.019) in the LBP group	-
Lamoth et al., (2006)	Case Control	LBP (n = 22) Control (17)	Non-specific LBP more than 3 months	Lumbal Erector Spinae	Amplitude activity on Lumbal Erector Spinae was higher in LBP group	-
Farahpour et al., (2018)	Case Control	LBP (n = 15) Control (n = 15)	Disability index > 10	TA, Gast-M, Vl, BF, Glut-M, ESL3, RA, IO, EO	In the LBP Peak group the EMG signal was higher in Glut-M, ESL3, IO, Gast-M, TA; There were no significant differences in Vl, BF, RA and EO	Glut-M: Control (48.4±27.3) LBP (111.8±48.6), ESL3: Control (28.0±9.6) LBP (40.1±14.4), Gast-M: Control (41.0±17.3) LBP (61.1±19.7), RA : Control (20.5±9.8) LBP (13.3±6.3), IO: Control (31.4±20.6) LBP (74.1 ± 46.2), EO: Control (22.5±19.9) LBP (26.5±11.5), RA: Control (20.5± 9.8) LBP (13.3 ± 6.3)
Hanada et al., (2011)	Cross Sectional Study	LBP (n = 9) Control (n = 9)	LBP more than 8 months	LES, LM and LRA	amplitude activity in the LES 6% MVIC was higher in the LBP group, right and left LRA amplitudes had a substantial main effect group (P<.001) with right and left LRA activities in the LBP group were 3.5% MVIC and 6.5% respectively, and MVIC was smaller in LBP group.	-

(*continued*)

Table 2. (*continued*)

AUTHOR (YEAR)	STUDY DESIGN	SAMPLE	LBP SYMPTOM	MUSCLE	OUTCOME	RESULT
Arendt-Nielsen et al., (1996)	Cohort Study	LBP (n = 10) Control (n = 10)	Diagnosis Idiopatic LBP ; Pain intensity more than 3 to 10	Th12, L2 and L$	In LBP group, amplitudo activity in Th12, L2 and L4 was higher	Th12: Control (35.9 5±13.5) LBP (46.25±13.8), L2: Control (35.5±10.4) LBP (55.4±17.6), L4: Control (29.3±9.6) LBP (46.4±19.7)
Ansari et al., (2018)	Cross Sectional Study	LBP (n = 21) Control (n = 21)	LBP more than 3 months	MF and ES	In LBP group, amplitudo acitivity in ES and MF was higher	ES: Control (293.2±199.98) LBP (401.7±318.1), MF: Control (114±74.2) LBP (210.4±116.63)
Arjunan et al., (2018)	Case Control	LBP (n = 4) Control (n = 9)	LBP from 3 weeks to 4 months	ES in L1, L2 and MF in L3, L4	In LBP group, amplitudo acitivity in ES and MF was higher	MF: Control (9.03E-01±6.4E-01) LBP (1.67E+00±1.5E+00), ES: Control (8.32E-01±5.1E-01) LBP(1.16E+00±1.02E +00)
Van der Hulst et al., (2010)	Cross Sectional Study	LBP (n = 63) Control (n = 33)	LBP more than 3 months	L1, L4	In LBP group, amplitudo activity in L1 and L4 was higher	L1: Control (21.0±7.9) LBP (26.0±12.8), L4: Control (21.2±7.8) LBP (30.2±15.8)

LRA: Lower Rectus abdominis, LES: Lumbal Erector Spinae, LM: Lumbal Multifudus, ES: Erector Spinae, Vl: Vastus Lateralis, BF: Biceps Femoris, IO: Internal Oblique, Gast-M: Gastrocnemious Medialis, Glut-M: Gluteus Medius, MF: Multifudus, EO: External Obliques, L: Lumbal, Th: Thoracal

Table 3. Study quality measurement results

Reference	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Study	Total	Percent
Kim et al., (2017)	v	v	-	v	*	v	v	-	-	*	v	-	-	-	v	v	CC	8/12	67
Lamoth et al., (2006)	v	v	-	v	*	-	v	-	-	*	v	-	v	-	v	v	CC	8/12	67
Farahpour et al., (2018)	v	-	v	v	*	-	v	-	-	*	-	-	-	-	v	v	CC	6/12	50
Arjunan et al., (2018)	v	v	-	v	*	-	v	-	-	*	-	-	-	-	v	-	CC	5/12	42
Hanada et al., (2011)	v	v	*	v	*	-	*	-	*	*	v	*	-	-	v	-	CS	5/8	63
Ansari et al., (2018)	v	v	*	v	*	-	*	-	*	*	v	*	-	-	v	v	CS	6/8	75
Van der Hulst et al., (2010)	v	v	*	v	*	-	v	-	*	*	-	*	v	-	v	v	CS	7/8	88
Arendt-Nielsen et al.,(1996)	v	v	*	v	v	-	*	-	*	-	v	*	-	-	v	-	PC	6/9	67

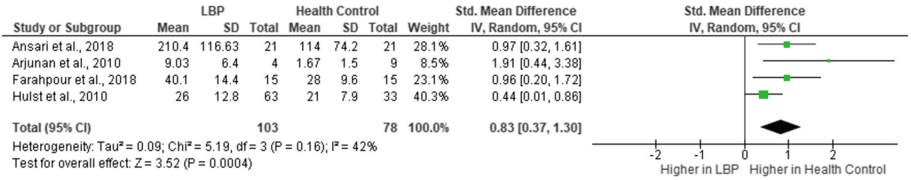

Fig. 2. Forest Plot Paraspinal Activation

3.2.2 Abdominal Muscle Movement

Based on the collected data, 2 studies showed no major difference in rectus abdominis activity in the LBP category and the control group [34, 37]. This is different from the study by Hanada et al., (2011) who stated that the rectus abdominis amplitude activity was lower in the LBP group, while Hulst et al., (2010) reported higher rectus abdmmonal activity in the LBP group [38, 39]. There was no discernible difference in the muscle movement of the two groups between the two groups according to 4 studies on external oblique activity [37–39] and [43]. In 2 studies, the LBP group showed less internal oblique activity [39, 43].

3.3 Meta-analysis

From the 4 studies used, data on muscle movement were collected from a total of 181 participants in both groups while walking as measured by EMG on the lumbar paraspinal muscles. The findings revealed that people who have LBP had a higher amplitude activity

compared to controls (SMD: 0.83, 95%Cl: 0.37 to 1.3, effect $p = 0.0004$, I^2: 42%, X^2 p: 3.52) (Figure 2).

4 Discussion

In order to ascertain difference in muscle movement while walking in the LBP group compared to healthy ones, the findings of the systematic review and meta- analysis in this study were drawn from a number of studies. In 8 trials, both LBP patients and healthy controls had their muscle movement assessed using EMG. EMG is a reliable indicator of muscle movement in the multifidus and abdomen, according to 2 studies [44, 45]. The 8 studies used indicate that there are significant differences in muscle movement during walking between the LBP group and healthy controls.

4.1 Muscle Movement Trunk Measurements

Farahpour et al., (2018) measured muscle movement in 15 LBP individuals with pronated foot (PF) compared to 15 healthy control individuals and found that erector spinae muscle movement in lumbar 3 was more frequent in the LBP category with PF than in the control category, but it was not clear whether the increase this muscle movement was due to PF in LBP [37]. According to Lamoth et al., (2006), the LBP group had higher average lumbar erector spinae activity as the swing phase commenced. Measurements were taken on a treadmill by asking both groups to choose a comfortable walking speed. The LBP group typically chose to walk at a slower pace than the healthy group; this may be because they had spinal structural dysfunction or had difficulty controlling their trunk muscles, resulting in spinal instability [20].

Hanada et al., (2011) also found the same thing, where the LBP group would walk slower with shorter steps. Left LES movement was observed to be stronger in the LBP group in measurements made at 4 walking cycles (left loading response, left mid stance, right loading response, and right mid stance). The left LES activity in both groups was higher during the loading response cycle than it was in mid-stance, while the left LES activity in both groups was lower during the right loading response than it was during the left loading response [39]. Ansari et al., (2018) used an EMG electrode to evaluate the activity of the multifudus muscles by putting it 2 cm laterally on the L5 spinous process and 4 cm laterally on the L1 spinous process. According to these measurements, multifid activity was generally more frequent in the LBP group, although significant difference was not found between the two groups' erector spinae activity levels [40].

When muscle pain occurs, it will be followed by increased muscle movement, which may be explained by a model of pain adaptation where there is an interaction between motor performance and pain [20] or by sensory nerves in the paraspinal muscles and certain connective tissue in the spine. Sensitive to modifications in movement that might be brought on by pain. The sensory nerves will increase and inhibit muscle movement in response to changes in movement [46].

Erector spinae activity at L1 and L2 as well as multifidus activity at L4 and L5 were measured by Arjun et al., (2018) during walking movements and no significant difference in activity was discovered. However, when doing running movements a major

increase was found in the LBP group. Accordingly, EMG recordings at L4 and L5 can be utilized as a measuring tool to identify LBP patients [42]. The electrodes at L4 and L5 exhibited more considerable variation between the LBP group and control group than the electrodes at L1 and L2. Arendt-Nielsen et al., (1996) positioned electrodes on the Th12 spinous process, L2 spinous process, and L4 spinous process in their investigation in order to capture muscle movement. Recording was carried out 8 times and the average EMG activity in the contralateral swing phase ($P < 0.045$) and ipsilateral swing phase ($P < 0.019$) increased significantly in the LBP group compared to controls [41].

4.2 Muscle Movement Abdominal Measurements

Hanada et al., (2011) discovered no statistically major differences in the amplitude of the left internal obliques or the rectus abdominis in the LBP category in comparison to the control group. The right internal obliques and rectus abdominis both have responses that are unrelated to dynamic changes during walking movements, which may explain why their amplitude activity was lower in the LBP group [39].

Kim et al., (2017) measured the activity of the rectus abdominis by placing an electrode 2 cm laterally from the umbilicus. They found no major difference between the two groups' rectus abdominis activity, though the LBP group tended to have less activity. Both the internal and external obliques were measured, but only the internal obliques on the right side demonstrated a statistically major difference in activity, whereas the external obliques did not show a significant difference but tended to be less active in the LBP group. Right internal oblique activity was typically lower in the LBP group than in the control group [43]. Farahpour et al., (2018) also demonstrated that there was no appreciable difference in the activity of the rectus abdominis and external obliques, but that the internal obliques activity was lower in the control group than in the LBP group [37]. Hulst et al., (2010) revealed that the activity of the rectus abdominis was higher in the LBP group, but there was still no significant difference in the activity of the external obliques [38]. What distinguishes this study from previous studies is that no review was carried out in this study regarding sptiotemporal characteristics and kinetic characteristics.

The study has several limitations, including the dearth of studies that examine abdominal muscle movement and the wide range of opinions that are expressed in those studies. It is hoped that future research will be able to discuss the pattern of abdominal muscle movement in more detail because there are still varying views on abdominal muscle movement. Additionally, we believe that in order to obtain accurate results of muscle movement, variations in walking speed and duration must be included.

5 Conclusion

Based on the findings of a systematic review and meta-analysis, it can be said generally that there are major differences in muscle movement during walking movements between the LBP group and the control group, with the LBP group showing a particularly significant increase in trunk muscle movement. In this research, abdominal muscle pattern is still unclear. Given the differences in muscle movement that have been observed in

LBP patients, clinically, this study will be very helpful to study the impact of different rehabilitation regimens by observing the altered pattern of muscle movement in LBP patients. As a result, it can assist physiotherapists in integrating the best treatment based on the patient's condition.

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