RESEARCH PAPER

PREVALENCE OF PATELLOFEMORAL PAIN SYNDROME IN ADOLESCENT CYCLISTS

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ABSTRACT

Background: Patellofemoral Pain Syndrome (PFPS) is the most common causes of knee pain in adolescents, particularly affecting those who are physically active. It is characterized by diffuse anterior knee pain, often aggravated by activities such as running, squatting, or climbing stairs. Despite its high incidence, PFPS is often underdiagnosed or mismanaged in young populations, potentially leading to chronic pain and functional limitations.

Objective: To determine the prevalence of PFPS among adolescents aged 12–18 years and to identify potential contributing factors such as gender, physical activity levels, and body mass index (BMI).

Methods: A cross-sectional survey was conducted among 255 school-going adolescents using a validated questionnaire, clinical screening tests (Clarke's test, patellar compression test), and physical activity assessment tools. Inclusion criteria includes adolescents with knee pain more than 4 weeks. Exclusion criteria involved traumatic injuries or diagnosed systemic conditions. Statistical analysis was performed to determine prevalence and associated risk factors.

Results: The prevalence of PFPS among the study population was found to be 22.6%, with a higher incidence in females (28%) than males (17%). Adolescents involved in high-impact sports and those with a higher BMI showed a significantly greater risk. Symptoms are more common in those with poor lower limb alignment and muscle imbalances.

Conclusion: PFPS is a prevalent condition among adolescents, particularly in females and those with high physical activity or elevated BMI. Early identification through school-based screening programs and awareness can help in timely intervention, preventing long-term complications and disability.

Keywords: Patellofemoral pain syndrome, adolescents, knee pain, prevalence, physical activity, musculoskeletal disorders, risk factors, BMI.

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INTRODUCTION

Cycling is a popular activity among individuals for recreation, competition, or fitness purposes. In adolescents aged 11 to 20, it offers numerous benefits for mental, physical, and social health. Engaging in regular cycling can lead to improved cardiovascular fitness, enhanced muscular strength, reduced obesity risk and decreased levels of stress and anxiety. Cycling accounts for the highest number of injuries compared to other sports. The most common site of overuse injury is the knee joint. Bicycle injuries can be categorized into three types: contact injuries (from collisions) traumatic injuries (from sudden impacts), and overuse injuries (from repetitive strain). Friction related overload injuries are a more common and often overlooked source of knee pain in cyclists compared to patellofemoral cartilage overload. However, patellofemoral pain syndrome (PFPS) is a common cause of knee discomfort among adolescents.[1] The patellofemoral joint plays a key role in proper knee function by adjusting the direction of force during quadriceps muscle activity - from a diagonal, upward, and lateral vector to a more vertical path. Knee

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pain in adolescents can lead to functional limitations, disrupting daily activities and negatively impacting their academic performance. PFPS typically manifests as widespread anterior knee pain, especially during activities that put pressure on the knee, such as squatting, running, or using stairs. Due to the repetitive nature of cycling, it poses a significant risk for PFPS, potentially impacting performance and well-being.[2] Preventive measures like proper training and warm up routines can help reduce the likelihood of overuse injuries in cyclists. Though cycling is generally considered a low impact activity suitable for varied fitness goals, competitive cycling introduces increased physical stress, heightening injury risk.[2]

With a gradual, non-traumatic onset, the pain is triggered by activities that increase compressive forces on the patellofemoral joint. The ethology of PFPS is multifactorial, often linked to knee stress, poor patellar tracking, and altered biomechanics. contributing factors include lower limb misalignment, muscular imbalance, and overactivity. Quadriceps dysfunction may disrupt patellar movement, leading to malalignment and pain.[3]

Reduced soft tissue flexibility can disturb patellofemoral joint equilibrium. Changes in patella's surrounding tissues, bone structure, and blood flow. these mechanical and inflammatory changes might contribute to cartilage degeneration due to increased joint pressure.[4] Although PFPS is influenced by multiple factors, muscular imbalances are thought to significantly contribute to patellar mal-tracking. One such imbalance involves the vastus medialis obliques (VMO), when the VMO is weak or insufficient, it may fail to adequately oppose the lateral force exerted by the vastus lateralis, potentially leading to improper tracking of patella.[5]

VMO muscle activates in a way that causes abnormal patellar movement 1. Increased medial patellar rotation: the kneecap rotates more inward than normal. 2. Increased anterior patellar translation: the kneecap moves more forward than normal. This abnormal movement pattern may contribute to pain and dysfunction in knee.

Among elite cyclists, 26% reported experiencing knee pain, with anterior knee discomfort and spinal issues also prevalent in 41% of cases. [6]The primary factors linked to unspecified knee pain in adolescents include being female, participating in sports activities, and obesity. Research says that girls are significantly at higher risk, about four times more likely to experience knee pain compared to boys. Developing appropriate training regimens that include load management and rest period can prevent overuse injuries like PFPS. Preventing reoccurrence requires ongoing treatment, monitoring strength training. educating cyclists about proper technique, injury prevention measures can significantly reduce the prevalence of PFPS and improve overall cycling health.

Skeletal muscle strength is closely linked to the quality and structural organization of the muscle.[5] The structural properties of muscles, such as thickness and cross-sectional area, significantly influence their ability to generate force and function effectively during various movements. Muscle quality can be impaired when fat and connective tissue accumulate within the muscle, changing its overall structure and function. This can cause impairments in muscle strength associated with muscle disuse.[6]

Our purpose was to determine prevalence of patellofemoral pain syndrome and non invasively patellar tracking pattern induced by activation of quadriceps in subject with PFPS to healthy subjects.[4]

The number of male and female adolescents of age between 11 to 20 were assessed using special tests and subjects age, gender, height, weight, BMI, in students group. Special tests for assessment, manual muscle testing are used in determining the study of prevalence. In light of these issues, the present study is designed to assess the prevalence of patellofemoral pain syndrome in adolescent patients and to evaluate their impact on functional outcomes and quality of life.[8]

INCLUSION CRITERIA

1. Adolescent age group 11 to 30 years. Active cyclists who engaged in cyclists at least 3 times per week.
2. The cyclists who are reported pain discomfort symptoms consistent with PFPS in anteropatellar or peri patellar region of knee.
3. Healthy adolescents with no significant underlying systemic diseases (arthritis , metabolic disorders) or previous knee surgeries.

EXCLUSION CRITERIA

1. Adolescents who have undergone major knee surgeries (example. ACL reconstruction, patella realighnment) should be excluded.
2. Exclude participants with recent acute injury for trauma to knee.

ETHICAL COMMITTEE APPROVAL

The approval for this study is gained from the institutional ethics committee of Krishna Vishwa Vidyapeeth (deemed to be university), Karad. Respondents were given a detailed explaination about data collection sheet as well the study which is to be conducted and written informed consent was secured from each collected from each participant participating in this study. there was a volunteer involvement of all the respondents in this study whose confidentiality was thoroughly maintained.

METHODS

A cross sectional study was conducted on adolescent cyclists aged 11-20 years. Clinical assessment involved

the use of visual analogue scale, special tests, crepitus test, manual muscle strength test.

1)**Visual analogue scale (VAS)**

Participants rated their pain on a 0-10 scale, both at rest and after cycling activity.

Pain more or equal to 4/10 during or after cycling was deemed to have clinical importance for PFPS.

2) **Crepitus tes**t: patient lies in supine and one hand of examiner should be positioned over patella. ask patient to contract the quadriceps muscle or slowly flex and extend the knee. A grinding or crackling sound under examiners hand is positive sign.

3) **patellar grind test**: patient lies in supine with legs extended. examiner places one hand superior to patella and gently press inferiorly. if pain it indicates patellofemoral joint irritation.

4)**single leg squat test**: patient stands on one leg, arms across the chest. Patient is instructed to slowly perform a squat to about 40 to 50 degree, if pain persists test is positive.

5) **manual muscle testing**: MMT of quadriceps, hamstrings was performed using standardized grading scale (0-5). Weakness in the muscles was noted as potential risk factor.

STATISTICAL ANALYSIS

A study based on observation was undertaken and carried out among 225 adolescents. The study was conducted by taking assessment of adolescents, checking the strength of lower limbs, assessing by using special tests. Data collection was been made which included name, age, gender, cycling duration, pain, crepitus, special tests, manual muscle strength testing. The study duration was of 6 months. The random sampling method was used because of limited time. the collected data was analysed by a statistician using an instat application. Chi square test was done to analyse. Data collection sheets have been filled up by the adolescents who aged between 11-20 years. All variables were presented as percentages, means with standard deviations, and medians. Statistical significance was assessed using the Chi-square test. Data were entered into a spreadsheet using Microsoft Excel 2013

RESULTS AND INTERPRETATION-

PREVALENCE OF PATELLOFEMORAL PAIN SYNDROME AMONGS ADOLESCENTS CYCLISTS

- **TABLE 1**

PAIN ON NPRS : PAIN AMONG MALES

	AT REST	ON ACTIVITY	Chi square	P value
NO PAIN	13(12.60 %)	2 (1.94%)	19.432	0.0021
MILD PAIN	63 (61.1%)	47 (45.6%)		
MODERATE PAIN	22 (21.3%)	45 (43.6%)		
SEVERE PAIN	5 (4.85%)	9(8.73%)		
	103	103		

PAIN ON NPRS AMONG FEMALES

Pain Assessment (Numerical Pain Rating Scale - NPRS)

At Rest:

PFPS Negative: 2.18

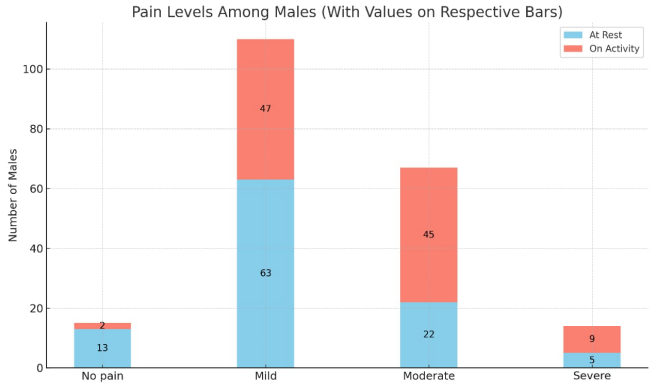
PFPS Positive: 3.16

During Activity:

PFPS Negative: 3.50

PFPS Positive: 4.57

Interpretation: Adolescents diagnosed with PFPS reported higher pain scores both at rest and during activity, confirming the impact of PFPS on pain perception and functional limitations. Increased pain during activity aligns with the clinical presentation of PFPS, which is typically aggravated by physical exertion involving the patellofemoral joint



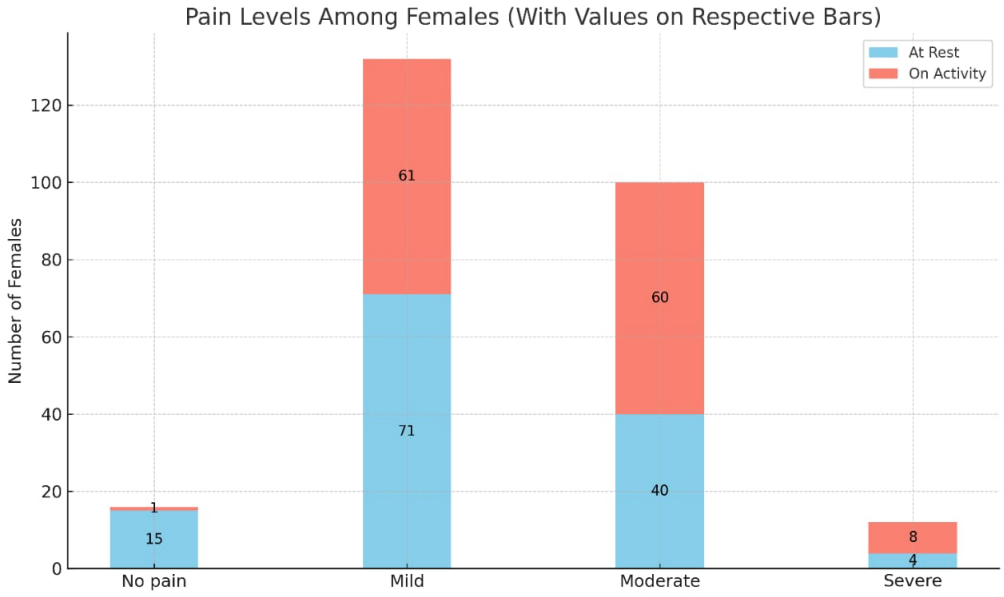
(Fig 1. Of Table 1.)

- **Table 2**

	At rest	On activity	Chi square	P value
No pain	15 (11.5%)	1(0.76%)	18.341	0.0004
Mild pain	71(54.6%)	61(46.9%)		
Moderate pain	40(30.7%)	60(46.1%)		
Severe pain	4(3.07%)	8(6.15%)		
	130 (100%)	130(100%)		

Interpretation

A significant association was found between pain levels at rest and during activity (Chi-square = 18.341, p = 0.0004). Most participants reported mild pain at rest (54.6%), which increased to moderate pain during activity (46.1%). Severe pain was relatively low but showed an increase with activity. This indicates that activity exacerbates pain intensity among the participants.



(Fig 2 of table 2)

The correlation between the patellofemoral pain on NPRS at rest and on activity

Correlation	Mean+-	P value

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	Standard deviation	
patellofemoral pain on NPRS at rest	**2.52 1.810**	**<0.0001**
patellofemoral pain on NPRS on activity	**3.87 1.70**	**<0.0001**

The correlation analysis revealed that patellofemoral pain measured on the Numerical Pain Rating Scale (NPRS) was significantly higher during activity (Mean = 3.87 ± 1.70) compared to rest (Mean = 2.52 ± 1.81), with a highly significant p-value (<0.0001). This indicates that physical activity such as cycling markedly exacerbates anterior knee pain in adolescents with PFPS. The results confirm that PFPS is an activity-related condition, where repetitive stress on the patellofemoral joint leads to greater discomfort during dynamic movements than during rest.

- **TABLE 3**

AGE GROUP DISTRUBUTION BY GENDER

Age group/ gender	male	female	Chi square	P value
0-10 years	2	0	2.549	0.2796
11-15years	97	123		
16-20years	5	7		

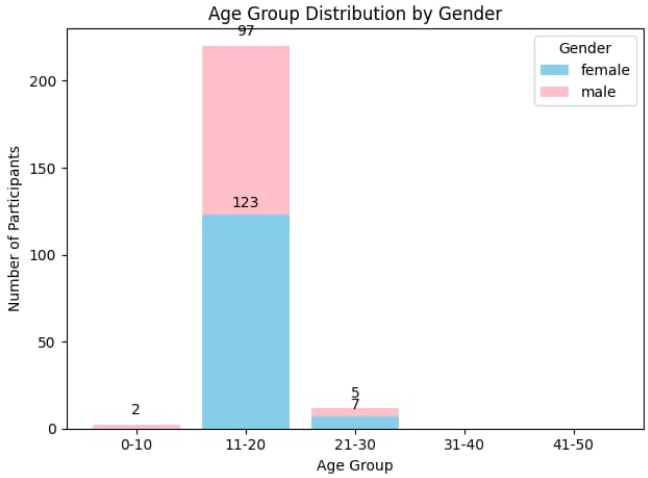
NUMBER OF MALE AND FEMALE PARTICIPANTS

Gender-Wise Distribution

Female adolescents: 31.54%

Male adolescents: 38.83%

Interpretation: Contrary to commonly reported trends in literature, where females often exhibit higher PFPS rates, this dataset demonstrates a slightly higher prevalence in males*. This may reflect gender-based differences in activity types, biomechanics, or sampling variability.



(Fig 3 of table 3)

TABLE 4

1:	MALE	FEMALE
2:	103	130

Age-Wise Distribution

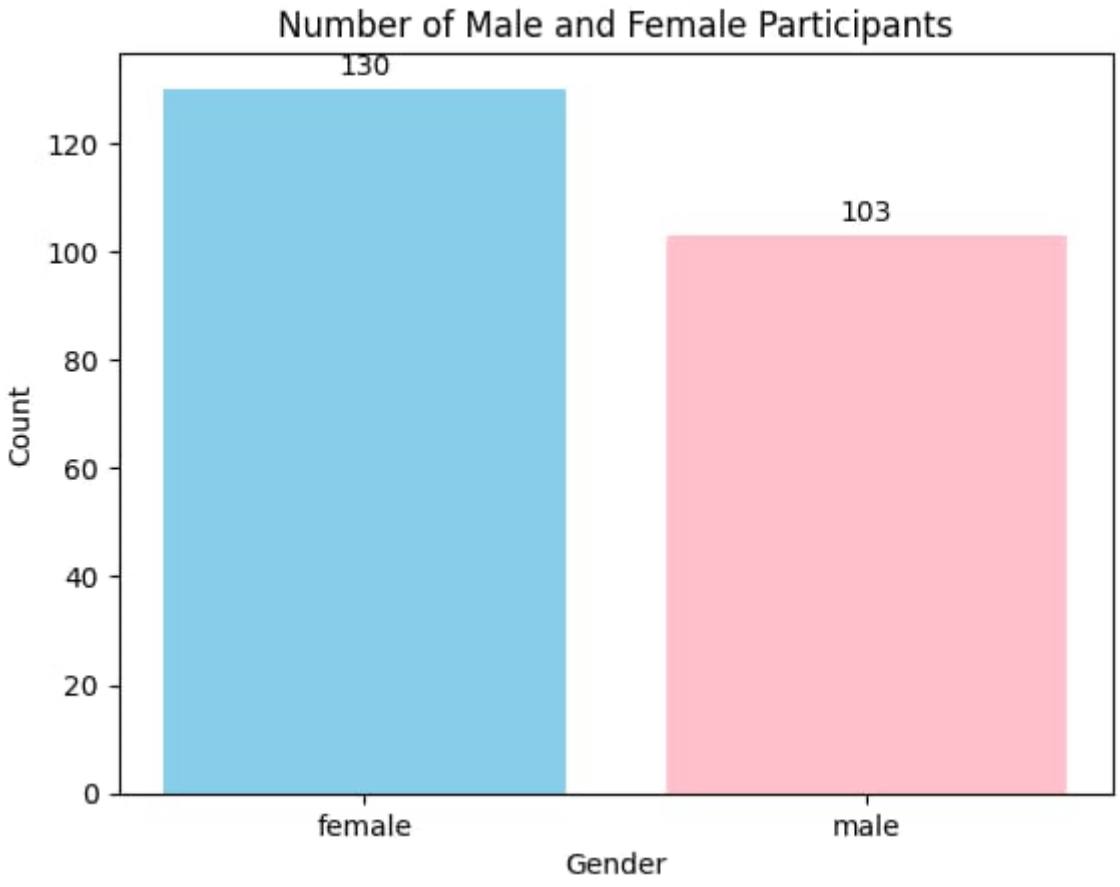
The prevalence of PFPS varied across different age groups:

0–10 years: 27.78%

11–15 years: 49.02%

16–20years: 28.07%

Interpretation: The peak prevalence was observed in the 14–15-year age group, suggesting a crucial time in early teenage years when probability of developing PFPS is highest, possibly due to rapid musculoskeletal development and a rise in physical activity observed during puberty.



(Fig 4 of table 4)

DISCUSSION-

The findings of this study confirm that Patellofemoral Pain Syndrome (PFPS) is a frequent problem among adolescent cyclists, and symptoms were significantly aggravated during activity compared to rest 【3】. This mirrors the review by Smith et al., who concluded that PFPS is one of the most common musculoskeletal disorders in adolescents and athletes, with activity-related pain being the defining feature 【3】.

In the present study, both male and female participants showed a marked increase in pain scores during activity. This supports the work of Piotrowska, who found that repetitive knee loading in cyclists leads to high occurrences of anterior knee pain, further emphasizing that sport-specific stresses contribute directly to symptom severity 【5】.

The observation that mild pain at rest shifted toward moderate pain during cycling activity is consistent with Rathleff et al., who demonstrated that dynamic or sustained activities—such as prolonged sitting, squatting, or cycling—exacerbate anterior knee discomfort, highlighting the functional limitations imposed by PFPS 【6】.

Interestingly, the current results showed slightly higher PFPS prevalence among males, contrasting with Myer et al., who identified female athletes as being at greater risk due to factors such as wider pelvic angles, altered hip kinematics, and reduced quadriceps strength 【4】. This difference may be explained by variations in training load, cycling biomechanics, or cultural influences on sports participation. Similar deviations were highlighted by epidemiological surveys that reported no consistent gender difference in PFPS when specific activity patterns were considered 【10】.

The highest prevalence was noted in the 14–15-year age group, after which the frequency declined. This corresponds with findings from anatomical reviews of PFPS risk factors, which emphasize that pubertal growth spurts create musculoskeletal imbalances, especially when bone growth outpaces muscular adaptation, thereby predisposing adolescents to knee pain 【7】.

Comparable results were presented by studies on patellar tracking and Vastus Medialis Obliquus (VMO) function, which showed that muscle weakness during rapid growth phases leads to abnormal patellar rotation and translation, further contributing to pain during activity 【8】.

PFPS symptoms typically intensify with load-bearing and repetitive activities, such as squatting, stair climbing, or cycling, due to increased compressive forces across the patellofemoral joint 【1,3,6】. The significant difference between rest and activity pain scores highlights the functional limitations caused by PFPS and underscores the importance of targeted rehabilitation aimed at reducing pain during activity through strengthening and biomechanical correction 【2,5,9】.

Our findings underline the importance of identifying malalignment, muscular imbalance, and quadriceps weakness early. This aligns with the application of clinical tools such as the Oxford Scale and manual muscle testing, which have been shown effective in detecting functional deficits in adolescents with PFPS 【9】.

Preventive interventions are crucial. As highlighted by Bini et al., cycling biomechanics, including pedal force effectiveness and bike fitting, play a central role in either reducing or aggravating knee stress, meaning that training modifications can prevent PFPS onset 【2】. Similarly, Pendleton et al. stressed that abnormal muscle activation patterns in cyclists lead to patellar maltracking, reinforcing the need for neuromuscular training in young athletes 【1】.

Taken together, the current study reinforces that PFPS is a multifactorial disorder influenced by biomechanics, growth-related changes, and training load. Early screening, strength training for quadriceps and hip muscles, proper bike fitting, and education about overuse prevention are necessary to reduce the prevalence and long-term consequences of PFPS in adolescent cyclists 【10】.

CONCLUSION-

This study demonstrates that Patellofemoral Pain Syndrome (PFPS) is a common issue in adolescent cyclists, with pain levels increasing notably during physical activity compared to periods of rest. The peak prevalence observed in the 14–15-year age group suggests that puberty is a particularly vulnerable stage, likely due to rapid skeletal growth combined with increased physical demands. While many earlier reports have shown higher rates of PFPS in females, our findings indicated slightly greater prevalence in males, pointing toward possible influences of sport-specific participation patterns and biomechanical variations.

The evidence supports that PFPS arises from multiple interacting factors, including lower-limb malalignment, muscle weakness, and repetitive strain on the knee joint. Therefore, early screening and identification of risk markers are essential. Preventive approaches such as hip and quadriceps strengthening, appropriate bike setup, and structured training loads should be incorporated to reduce risk. Overall, the study underscores the need for preventive and rehabilitative strategies in adolescent

cycling to safeguard knee health and promote long-term athletic participation.

LIMITATIONS

This study had several limitations that should be considered when interpreting the findings. First, the cross-sectional design restricts the ability to establish causal relationships between cycling activity and the development of PFPS. Second, the sample was limited to adolescent cyclists from a specific region, which may reduce the generalizability of the results to broader populations. Third, training load variables such as cycling intensity, duration, and terrain were not comprehensively recorded, which could have influenced pain prevalence and severity. Fourth, the reliance on clinical tests and self-reported pain measures, without imaging or biomechanical assessment, may have introduced subjectivity and potential diagnostic bias. Lastly, the relatively short duration of data collection may not fully capture seasonal variations in training or symptom patterns.

FUTURE SCOPE

Expanding the participant pool across diverse regions and cycling clubs would enhance the generalizability of outcomes and allow for more detailed subgroup comparisons. Integrating objective biomechanical tools such as gait analysis, electromyographic assessments of muscle activity, and advanced imaging could offer a deeper understanding of the pathomechanics underlying PFPS in adolescent cyclists. Moreover, future investigations should focus on the influence of training load, cycling posture, and individualized bike-fit parameters, as these variables are likely to play a significant role in knee stress and the development of PFPS.

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