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THE CORRELATION BETWEEN LIFESTYLE AND PREVALENCE OF KNEE JOINT DISEASE IN PLATEAU AREAS

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Abstract: The high incidence of knee osteoarthritis (KOA) in the plateau has become an important public health issue . The unique geographical environment of the plateau has multiple impacts on the joint health of residents . Clinical studies have shown that the prevalence of knee osteoarthritis (KOA) in plateau residents is significantly higher than that in the plains, and can even be up to three times that of the plains. This difference is not only closely related to the special geographical and climatic conditions of the plateau, but also affected by the unique lifestyle of local residents . The combined effect of environmental factors and lifestyle has made knee joint diseases in this region appear younger and more severe. This article will systematically sort out the multidimensional research framework of the special geographical environment and lifestyle of the plateau and the prevalence of knee joint diseases from seven dimensions. The main contents are as follows: (1) Research background overview: Introducing the high incidence of plateau knee arthritis and its research value; (2) Geographical influence mechanisms: Analyze the mechanisms of high altitude, low oxygen, cold weather, and other factors, and use tables to compare data; (3) Special lifestyle influences: Explore the role of lifestyle factors such as working posture and diet structure; (4) Population distribution characteristics: Summarize the differences in prevalence by sex, age, and ethnicity, using comparative tables; (5) Disease characteristics and impact: Describe the clinical presentation, imaging features, and socioeconomic burden of the disease; (6) Prevention and treatment strategy recommendations: Propose a three-level prevention system and an “active health management” model; (7) Research Outlook: Point out the future research direction.
Keywords: Plateau area; High Incidence of Knee Osteoarthritis (KOA)

1 INTRODUCTION

Statistics show that over 50% of people over 60 in Qinghai suffer from varying degrees of degenerative knee disease. A survey of 632 patients seeking treatment for bone and joint discomfort at the Affiliated Hospital of Qinghai University found 600 valid responses, with 552 meeting a diagnosis of knee osteoarthritis, representing a prevalence rate of 92%.
A survey in Ngari Prefecture, Tibet region, revealed that among 100 patients with knee osteoarthritis, the proportion of women was significantly higher than that of men (male:female ratio:1:1.6), and women tended to develop the disease at an earlier age (average age:46 for women vs. 51 for men). Radiographic examinations revealed that 56.8 % of patients exhibited grade III-IV knee joint changes, and 64.8 % had abnormalities of the medial tibiofemoral joint, far exceeding the proportions of lesions in the lateral and patellofemoral joints. This disease resulted in a significant decrease in or even complete loss of work ability in 20.8 % of patients due to joint problems , severely impacting the productivity and daily lives of residents in the region.
A comparative study in the Hexi region of Gansu further reveals the impact of living environment on joint health: the prevalence of osteoarthritis in pastoral areas (2000-3500 meters above sea level) is as high as 39.3%, while in the lower, warmer agricultural areas (1000-1500 meters above sea level), the prevalence is only 10.6%. This nearly four-fold difference points to the potential harms of high altitude, cold climate, and pastoral lifestyle.
Research on the Diqing Plateau in Yunnan Province reinforced this conclusion - the overall prevalence of KOA among middle-aged and elderly people in the region reached 38.4%, significantly higher than that in plain (low-altitude) areas such as Beijing and Shanghai , among which the prevalence among people in Tibet region was as high as 53.9 % .
These studies together depict a grim reality: the plateau environment and its specific lifestyle constitute a unique risk matrix for joint degeneration, and there is an urgent need to analyze its mechanism of action from multiple dimensions to provide a scientific basis for targeted prevention and treatment.

2 MECHANISM OF THE IMPACT OF GEOGRAPHICAL ENVIRONMENT ON KNEE JOINT DISEASE

The uniqueness of the plateau environment lies in the combined effects of multiple natural factors: high altitude, low temperature, strong ultraviolet radiation, special geochemical composition, etc. These factors together pose special challenges to joint health.

2.1 Hypoxic Environment and Tissue Repair Disorders

The oxygen content of air in plateau regions is similar to that in plains, at 21%. However, as altitude increases, air density decreases, reducing the number of oxygen molecules per unit volume. This results in a decrease in the amount

of oxygen actually inhaled [1], leading to a chronic state of hypoxia. Articular cartilage, as an avascular tissue, undergoes changes in pressure within the joint cavity during joint movement (e.g., compression and relaxation of the cartilage during flexion and extension). This promotes the flow of synovial fluid through the micropores of the cartilage matrix, carrying nutrients such as oxygen, glucose, and amino acids to the cartilage cells (chondrocytes) while removing metabolic waste products (such as carbon dioxide and lactic acid). In this hypoxic environment, the metabolic activity and repair capacity of chondrocytes are significantly inhibited. Furthermore, hypoxia leads to an enhanced synovial inflammatory response, promoting the release of inflammatory cytokines (such as IL-1β and TNF-α) and accelerating the breakdown of the cartilage matrix [2]. This persistent low-grade inflammatory state creates a breeding ground for the development of osteoarthritis and the ideal environmental conditions for the development of bone disease .

2.2 The Dual Effects of Cold and Dampness

In cold and damp environments, the knee joint may experience a variety of adverse reactions. Coldness can cause the blood vessels around the knee joint to constrict, reducing blood circulation and leading to a decrease in nutrient supply to the joint tissues, causing pain, stiffness, and limited mobility. A humid environment can increase the moisture content of the tissues surrounding the joints, making the joints more susceptible to the effects of cold and exacerbating pain and discomfort. Long-term exposure to such conditions can also induce or aggravate knee joint inflammation, such as osteoarthritis and rheumatoid arthritis. Medical aid teams in Nyingchi, Tibet region, found that the incidence of osteoarthritis is particularly high in areas with humid climates and long rainy seasons, such as Bomi and Zayu. Cold and damp environments not only directly affect the joints but can also indirectly affect joint function by changing residents' activity patterns (such as reducing outdoor activities).

2.3 Geochemical Factors

Certain plateau regions may experience trace element imbalances, such as low selenium and high fluoride levels. These elemental imbalances are closely linked to joint health. Research in Milin County, Tibet region, noted that high levels of calcium and magnesium salts in local drinking water (commonly known as "hard water") may lead to specific bone and joint lesions. Historically, Kashin-Beck disease (KBD) has been reported in plateau regions [3]. This disease is closely linked to fungal toxins (such as T-2 toxin) in local grains and a low selenium environment. While prevention and control measures have significantly reduced this incidence, its residual effects and pathological mechanisms remain a concern.

Table 1 Comparison of KOA Prevalence in Areas with Different Altitudes

Regional characteristics	Altitude range (meters)	KOA prevalence (%)	Study Area
High-altitude pastoral areas	2000-3500	39.3	Hexi Animal Husbandry Area, Gansu
mid-altitude agricultural areas	1000-1500	10.6	Hexi Agricultural Area, Gansu
Ultra-high altitude areas	3160	47.6	Nixi Township, Diqing, Yunnan
mid-altitude areas	1900	29.7	Jinjiang Town, Diqing, Yunnan

2.4 Impact of Topography

The rugged mountainous terrain of the plateau significantly increases the mechanical load on residents' joints during daily activities. Research from the Hexi region of Gansu Province clearly indicates that the rugged mountain roads in pastoral areas and grazing activities lead to severe joint wear, which is highly consistent with the "chronic strain" cause of osteoarthritis. Prolonged walking or standing on steep terrain causes abnormal stress distribution in the knee joint, particularly increased pressure on the medial tibiofemoral joint, explaining the predominance of medial compartment lesions on radiographic examinations (reaching 64.9% in Ngari Prefecture, Tibet region).

3 IMPACT OF SPECIAL LIFESTYLE ON KNEE JOINTS

Plateau residents have formed unique ways of living and working in the long process of adapting to the special environment. Although these behavioral patterns are culturally adaptable, they may become potential risk factors for joint health.

3.1 Work Posture and Joint Load

Pastoral residents, engaged in activities such as herding, milking, and crafting, often require prolonged periods of kneeling, sitting cross-legged, or squatting. These postures increase joint stress, particularly when squatting, where the knee joint bears pressure several times that of body weight, placing significant pressure on the articular cartilage and

meniscus. Maintaining these postures for extended periods can impair blood circulation around the knee joint , placing the knee in extreme flexion or varus, leading to abnormally concentrated pressure on the joint surface. A study in Milin County, Tibet region, found a significant correlation between sitting cross-legged and the occurrence of KOA (P=0.0225). Observations by the Guangdong Medical Aid Tibet Region Team in Nyingchi further confirmed that the local traditional custom of "climbing and kneeling" causes significant damage to joints. Furthermore, sitting cross-legged leads to prolonged inversion of the knee joint [4], accelerating wear of the medial joint surface and ultimately forming a typical varus deformity ("bow legs").

3.2 Metabolic Impacts of Dietary Structure

The high proportion of meat and dairy products in the diet of plateau residents may affect joint health through metabolic pathways. A high-fat, high-purine diet not only increases the risk of gout and arthritis , but the oxidative stress response can also induce joint inflammation and joint bone disease . A medical team from Linzhi Prefecture, Tibet region, pointed out that long-term consumption of high-purine foods such as beef, cheese, and mushrooms may lead to gout crystal deposition in joints and peripheral vascular disease. Furthermore, insufficient intake of fruits and vegetables in the diet, resulting in a deficiency of antioxidants, may weaken the body's ability to combat oxidative stress and accelerate chondrocyte aging.

3.3 Labor Intensity and Exercise Patterns

Pastoral activities often require long journeys and heavy loads, placing high mechanical loads on joints in low temperatures. Injuries often go unrepaired. Research in Milin County, Tibet region, shows that residents are relatively insensitive to seeking medical care and have a high tolerance for pain [5]. This leads to joint problems being neglected and treatment delayed. The Guangdong Medical Aid Tibet Region Team emphasized that untreated sports injuries in the high altitude region can lead to persistent high-load conditions on joints, gradually developing into chronic injuries and ultimately traumatic osteoarthritis.

3.4 Protective Awareness and Behavioral Patterns

Plateau residents lack adequate joint insulation during cold weather and rarely use protective gear (such as knee pads and walking sticks). Furthermore, neglect of early symptoms of joint discomfort is common, leading to delayed intervention. While these behavioral patterns are limited by economic conditions and access to medical resources, they do exacerbate joint degeneration.

4 POPULATION DISTRIBUTION CHARACTERISTICS AND SUSCEPTIBILITY FACTORS

The distribution of KOA in the plateau region shows significant differences in age, gender, and ethnicity, which reflect the complex role of factors such as genetics, hormones, and social roles in the occurrence of the disease.

4.1 Gender and Hormonal Factors

All data consistently show a significantly higher prevalence in women than in men, and the age of onset is earlier. In a study in the Ali region of Tibet region, the proportion of female patients reached 61.9 % , with the peak incidence occurring between the ages of 40 and 49; the peak for men was between the ages of 50 and 59. Data from the Diqing Plateau in Yunnan Province showed a significantly higher prevalence in women (47.7%) than in men (27.4%). This difference, in addition to anatomical factors (such as the larger Q angle in women leading to patellofemoral joint instability), is closely related to changes in estrogen levels. The Guangdong medical aid team in Tibet region observed an abnormally high proportion of women aged around 50 among patients with advanced KOA in the plateau [6], suggesting that the sudden drop in estrogen levels during perimenopause accelerates joint degeneration. Estrogen stimulates chondrocyte proliferation and increases chondrocyte number. It also promotes chondrocyte synthesis of cartilage matrix, such as collagen and proteoglycans, which helps maintain the normal structure and function of cartilage.

Estrogen inhibits cartilage degradation and has a protective effect on cartilage. It regulates inflammation within the joint, inhibiting the production of inflammatory factors and promoting collagen synthesis, while maintaining the balance of subchondral bone . After menopause , this protective effect is lost , and women may experience accelerated cartilage degeneration, making articular cartilage more susceptible to damage.

4.2 Age Factors

The prevalence of KOA increases with age . A study in the Hexi region of Gansu Province showed that the prevalence in pastoral areas was 17.0% among people aged 40-49, jumping to 51.1% among those aged 50-59, and reaching 61.7% among those aged 60-65. A survey in the Zhaosu region of Xinjiang found that the prevalence in the 60-70 age group reached as high as 38.28 % [7]. This age-related change is closely related to the cumulative damage to articular cartilage,

decreased repair capacity, and decreased muscle strength . Notably, KOA is not only more common in plateau areas, but also occurs at a significantly earlier age, suggesting that environmental factors accelerate the process of joint degeneration.

Table 2 Differences in KOA Prevalence among Different Ethnic Groups in the Plateau

nationality	Survey area	Prevalence (%)	Compare the differences
People in Tibet	Diqing, Yunnan	53.8	Significantly higher than other ethnic groups
Naxi people	Diqing, Yunnan	25.6	Lower than people in Tibet region but higher than Han Chinese in the plains
Other ethnic groups	Diqing, Yunnan	29.3	Lower than people in Tibet region
Han (agricultural area)	Hexi, Gansu	15.4	Significantly lower than ethnic minorities

4.3 Ethnic Differences and Genetic Susceptibility

A survey in the Diqing area of Yunnan revealed a significant phenomenon: the prevalence of KOA in the people in Tibet region population (53.8%) was significantly higher than that of the Naxi people (25.6%) and other ethnic groups (29.3%) in the same region. More significantly, in the Hexi pastoral area of Gansu, the prevalence of KOA among Han Chinese (48.1%) was not significantly different from that among ethnic minorities (38.1%). This result suggests that environmental exposure factors (such as high altitude and pastoral activities) may be more important than the influence of genetic background itself. Of course, the Guangdong medical aid team in Tibet region noted that severe KOA patients often show familial clustering, suggesting that specific genetic polymorphisms (such as collagen genes and inflammatory factor genes) may increase individual susceptibility.

5 DISEASE CHARACTERISTICS AND SOCIAL IMPACT

Plateau knee osteoarthritis exhibits unique patterns in clinical manifestations, imaging features, and social impact , profoundly affecting the quality of life and socioeconomic development of local residents.

5.1 Clinical Manifestations

Patients with plateau KOA experience pain, swelling, stiffness, limited mobility, friction or popping in the joints, and even deformities . Among 100 patients in Ngari Prefecture, Tibet region, 72 (74.2%) experienced joint tenderness, 61 (62.9%) experienced limited joint mobility, and 13 (13.4%) experienced joint swelling [8]. The pain was often triggered or aggravated by cold weather, and patients generally reported that joint symptoms worsened before weather changes. Functional limitations were most prominent in climbing, squatting, and long-distance walking, seriously affecting daily living abilities. The Guangdong medical aid team to Tibet region described a typical case: a woman in Tibet region, unable to walk more than 100 meters due to severe knee arthritis, relied on painkillers for nighttime pain, and ultimately underwent joint replacement to regain mobility.

5.2 Radiographic Characteristics

Radiographic changes in the knee joint are primarily characterized by medial tibiofemoral joint lesions, consistent with biomechanical analysis showing that approximately 60-70% of the knee joint load is transmitted medially. In a study from the Ali region of Tibet region, 64.9% of patients had medial tibiofemoral joint abnormalities due to prolonged grazing, kneeling, and cross-legged sitting , which increase stress on the medial tibiofemoral joint and accelerate cartilage wear. However, only 3.1% had lateral abnormalities, and 4.1% had patellofemoral joint abnormalities. Radiographic grading was predominantly grade III-IV (Kellgren-Lawrence classification), accounting for 56.7%. A study from the Zhaosu region of Xinjiang also showed a significantly higher prevalence of medial tibiofemoral joint lesions (31.05%) than lateral (11.91%) and patellofemoral (7.32%) joints. Furthermore, bilateral symmetry (53.8%) is another characteristic of plateau KOA, likely related to similar environmental stresses on both lower limbs.

5.3 Socioeconomic Burden

Joint dysfunction directly weakens workers' productivity. A survey in Ngari Prefecture, Tibet region, showed that 4.1% of patients completely lost their ability to perform housework and herd livestock due to KOA, 9.2% experienced a significant reduction in their workload , and 7.3 % experienced a sustained reduction in their workload by more than half . This data indicates that over 20% of patients have experienced substantial impairment in their ability to work . In high-altitude pastoral areas, reduced work capacity not only impacts family income but also leads to secondary health problems such as decreased cardiopulmonary function and increased osteoporosis due to reduced activity, creating a

vicious cycle. The Guangdong Medical Aid Tibet Region Team noted that since 2019 , Linzhi People's Hospital alone has performed joint replacements on over 200 patients with advanced KOA, reflecting the prevalence and severity of joint disease in the region.

6 PREVENTION AND TREATMENT STRATEGIES FOR PLATEAU KNEE ARTHRITIS

In view of the special cause chain of plateau diseases, a multi-level comprehensive prevention and treatment system needs to be established, covering the entire process from primary prevention to late-stage treatment, and combining modern medicine with traditional wisdom .

6.1 The Specific Implementation Path Includes a Three-Level Prevention System

The three-level prevention system for plateau knee arthritis focuses on "prevention before illness occurs, early treatment of illness, and prevention of serious illness from becoming severe." The specific contents are as follows:

6.1.1 Primary prevention (cause prevention): prevent the occurrence of disease

For people in the plateau who have not yet experienced knee joint discomfort, we can reduce the pathogenic factors at the source and lower the risk of disease.

(1) Improve living and working habits: avoid kneeling, sitting cross-legged or squatting for long periods of time to reduce continuous pressure on the knee joints; use tools (such as backpacks, carts) when carrying heavy objects to avoid excessive weight on the knee joints.

(2) Adapt to the plateau environment: Those who first enter the plateau should gradually adapt to the high-altitude hypoxic environment and avoid climbing too high; in cold seasons, pay attention to keeping the knee joints warm (such as wearing knee pads) to reduce joint metabolic disorders caused by vasoconstriction.

(3) Supplement key nutrients: Ensure the intake of calcium (such as dairy products, soy products) and vitamin D (such as moderate sun exposure, eating egg yolks) in the diet to maintain bone and cartilage health.

(4) Strengthen joint protection exercises: Perform daily muscle training around the knee joint (such as straight leg raises and wall squats) to strengthen the quadriceps and other muscles and improve joint stability.

6.1.2 Secondary prevention (early intervention): stopping disease progression

For people who have experienced early symptoms (such as intermittent knee pain and soreness after activities) but no obvious structural damage, early intervention should be made to delay the disease.

(1) Seek medical advice promptly: If you feel unwell, undergo X-ray, ultrasound, or other examinations promptly to determine whether there is early cartilage degeneration or synovial inflammation to avoid delaying treatment.

(2) Control the inducing factors: reduce heavy physical labor and strenuous exercise (such as long-term climbing and jumping), and use a cane to assist walking for a short period of time when necessary to reduce the load on the knee joint.

(3) Standard basic treatment: Use topical anti-inflammatory and analgesic drugs (such as non-steroidal ointments) or physical therapy (such as hot compresses and infrared irradiation) under the guidance of a doctor to relieve inflammation and pain.

(4) Regular follow-up monitoring: Review the knee joint condition every 3-6 months, dynamically observe structural changes such as cartilage and meniscus, and adjust the intervention plan in a timely manner.

6.1.3 Tertiary prevention (rehabilitation and prevention): reducing disability and improving prognosis

For patients with obvious joint structure damage (such as cartilage wear, meniscus tear, mild deformity) or functional impairment, it can prevent the disease from worsening and reduce disability.

(1) Strengthen clinical treatment: Select advanced treatment according to the condition, such as intra-articular injection of sodium hyaluronate (to improve joint lubrication), surgical treatment (such as meniscus repair, arthroscopic cleaning), etc., to repair damaged structures.

(2) Rehabilitation training: After surgery or during the stable period of the disease, joint range of motion training (such as slow flexion and extension) and muscle strength training are performed under the guidance of a rehabilitation therapist to restore knee joint function and avoid muscle atrophy.

(3) Use of assistive devices: For those with joint deformities or severe functional limitations, wearing customized orthotic braces (such as knee varus braces) or using walkers can improve the force line of the lower limbs and reduce joint pressure.

(4) Maintaining quality of life: adjusting lifestyle (such as choosing soft-soled shoes and avoiding climbing stairs), and providing psychological counseling when necessary to help patients adapt to the disease and reduce the psychological burden caused by functional disorders.

6.2 “Active Health Management” Model

The Guangdong Medical Aid Tibet Region Team has put forward the concept of "active health management" in practice, emphasizing the improvement of residents' self-management capabilities:

(1) Change your lifestyle habits: reduce climbing, kneeling and bowing; change the habit of sitting cross-legged; avoid squatting for long periods of time; strictly adjust your diet (increase vegetable intake and reduce high-fat and

high-purine foods); and control your weight.
(2) Strengthen joint protection: pay attention to moisture and cold prevention; use appropriate knee pads and other protective equipment during exercise; perform muscle relaxation exercises before and after activities; and apply braking protection in time after injury.
(3) Self-rehabilitation skills: self-massage; local hot compress; static fascia stretching; joint health exercises.
Targeted early disease intervention: Seek medical attention promptly after trauma and follow the doctor's orders for standardized rehabilitation; metabolic diseases such as gout must be strictly controlled scientifically according to the doctor's orders ; and preventive treatment for osteoporosis.

6.3 Community Screening and Promotion of Appropriate Technologies

Milin County, Tibet Region, has used portable ultrasound to screen people for knee discomfort, demonstrating a sensitivity of 0.93 for diagnosing knee arthritis (KOA), providing greater convenience for grassroots residents in the plateau. This low-cost imaging test is suitable for promotion in pastoral areas with limited medical resources. Furthermore, the Tibet Region Medical Aid Project has screened thousands of osteoarthritis patients through free clinics in rural areas and performed joint replacements on over 200 patients in the advanced stage, significantly improving their quality of life . Future efforts should strengthen knowledge and skills training for grassroots medical personnel in the plateau to enhance their ability to identify and implement basic interventions for KOA .

7 RESEARCH PROSPECTS

Although existing research has revealed the high incidence of plateau KOA and its correlation with the environment and lifestyle, many deeper issues remain to be explored:
(1) Gene-environment interaction studies: The molecular mechanisms of how the plateau's hypoxic and cold environment influences chondrocyte metabolic pathways (such as the HIF-1α signaling pathway and autophagy) need to be elucidated. Furthermore, comparative genomic studies between people in Tibet region and other high-altitude ethnic groups and plain populations are being conducted to identify genetic markers associated with environmental adaptability and joint degeneration. Genome-wide association studies (GWAS) of familial clusters may reveal new susceptibility genes.
(2) Prospective cohort study: Establish a long-term follow-up cohort of plateau residents to dynamically monitor the incidence and progression of KOA in populations living at different altitudes (e.g., 4500 meters in Ali, Tibet region vs. 3200 meters in Diqing, Yunnan vs. 2000 meters in Hexi, Gansu). Regularly collect clinical data and biological samples (blood and urine) to analyze the correlation between environmental exposure markers (e.g., hypoxia-inducible factors, oxidative stress products, and inflammatory cytokine profiles) and the rate of joint degeneration.
(3) Culturally adapted intervention research: Designing alternative behavioral programs that respect traditional culture while protecting joint health. For example, developing ergonomic herding tools to reduce joint stress; designing improved seating to avoid prolonged cross-legged sitting; and exploring scientific modifications to traditional diets (such as increasing antioxidant intake). These interventions should be co-designed with local residents to ensure cultural acceptability.
(4) Evaluation of Comprehensive Prevention and Control Models: Establish "medical and prevention integration" demonstration zones in typical plateau pastoral areas (such as Nagqu, Tibet region, and Yushu, Qinghai), integrating health education, lifestyle guidance, early screening, and stepped treatment. By comparing changes in KOA incidence, disability rates, and medical burden before and after intervention, the cost-effectiveness of prevention and control strategies will be evaluated, providing a basis for developing targeted joint health policies in plateau regions.

8 CONCLUSION

The above content integrates the core research dimensions of the prevalence of knee osteoarthritis in plateau areas, covering geographical environmental mechanisms, lifestyle influences, population distribution characteristics, and prevention and control strategies. The construction of the research framework needs to pay special attention to the interaction between the special plateau environment and human behavior patterns, while considering the design and evaluation of culturally adaptive intervention measures. The high incidence of knee osteoarthritis in the plateau is the product of the two-way interaction of environmental factors and human behavior . A deep understanding of this complex relationship will not only help improve the joint health of plateau residents, but also provide a unique perspective for understanding the environmental etiology of osteoarthritis. With the advancement of the concept of precision prevention and the development of plateau medicine, the construction of individualized intervention strategies based on multidimensional risk models will become the core direction of future research.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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