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Ginkgo biloba in Diverse Dementia Populations: A Narrative Review

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Abstract: *With the burden of dementia growing worldwide and its increasing prevalence, there is an urgent need for treatments that can effectively target the main mechanisms of the neurodegenerative process. A substantial level of hope lies in traditional herbal medicine, particularly Ginkgo biloba, which is believed to not only inhibit the neurodegenerative process but also to alleviate the neuropsychiatric symptoms of dementia. However, the current literature tends to overlook the demographic-specific effects of Ginkgo biloba, failing to adequately clarify its efficacy across diverse patient populations. In this context, we conducted a thorough search across multiple databases, focusing on the impact of Ginkgo biloba on age, sex, genetic phenotype, and type of dementia. Our findings revealed varied efficacy across demographic groups, with noticeable benefits in some populations and fewer adverse effects in others. In particular, we identified that groups of older adults with specific genetic markers showed the greatest improvements in cognition, suggesting a strong need for personalised therapeutic strategies that incorporate demographic factors into clinical decision-making. This review highlights the benefits of herbal medicine, particularly Ginkgo biloba, in tailored dementia care, although further research is needed to develop accurate treatment protocols for diverse patient populations.*

Keywords: *ginkgo biloba; dementia; cognitive function; demographic-specific effects; personalised medicine; genetic markers; herbal supplements.*

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1. Introduction

Dementia represents a growing global health challenge, affecting millions of people and placing an increasing burden on healthcare systems and caregivers (Xie et al., 2022). Specifically, it is a neurodegenerative disease characterised by progressive cognitive decline and encompassing many disorders, with Alzheimer's disease being the most prevalent (Weinmann et al., 2010). As the global population ages, the development of more effective treatment protocols becomes crucial. Consequently, *Ginkgo biloba* has gained attention in recent years for its neuroprotective properties and potential to slow cognitive decline (Tan et al., 2015).

The clinical implications of *Ginkgo biloba* in the treatment of neurodegenerative processes lies in its widespread availability and its use in traditional Chinese medicine for over 2000 years (Zhu et al., 2024). Despite *Ginkgo biloba*'s popularity, debates continue over its efficacy and mechanism of action in the central nervous system (DeKosky et al., 2008). Some studies have reported positive cognitive effects, mainly in attention and memory, in these patients, while other authors suggest that outcomes vary depending on dosage and treatment protocol (Tan et al., 2015). Furthermore, the current literature on this topic adopts a broad view across diverse populations, with noteworthy demographic-specific responses that may serve as a foundation for personalised treatment approaches, yet these responses are often overlooked (Zhu et al., 2024).

The purpose of this review is to examine the current literature on the effects of *Ginkgo biloba* in patients diagnosed with any form of dementia, with a specific focus on the key demographic factors that influence treatment response. Moreover, by analysing data across multiple studies, we aim to clarify the influence of factors such as age, sex, genetic background, and specific dementia types on treatment outcomes. In this way, our analysis addresses a significant gap in the research, promoting a better understanding of *Ginkgo biloba* effects within personalised treatment protocols.

This review highlights demographic discrepancies and aims to guide future research towards personalised medicine and the resolution of inconsistent findings. Understanding these differences could reform clinical approaches to dementia, allowing optimisation of *Ginkgo biloba*'s therapeutic efficacy and improvement of patient quality of life.

2. Materials and Methods

A comprehensive literature search was conducted across key electronic databases, including Web of Science, PubMed, Scopus, and Google Scholar, to identify relevant studies examining the demographic-specific effects of *Ginkgo biloba* in the treatment of major neurocognitive disorders. The search strategy combined terms such as “*Ginkgo biloba*”, “dementia”, “cognitive impairment”, “age differences”, “genetic factors”, and “ethnic variations”. The search period was restricted to studies published between January 1986 and December 2024 to incorporate both historical and contemporary research. Titles and abstracts were screened independently by two reviewers, with full texts retrieved for potentially eligible reports; disagreements were resolved by discussion or a third reviewer. We extracted key study characteristics (sample size, age strata, gender, ethnicity, genetic markers when reported), intervention details (*Ginkgo* preparation, dose, duration), outcome measures (cognitive scales, functional outcomes), and main results using a standardized extraction form.

The selection process involved multiple stages to ensure the inclusion of relevant, high-quality research. Inclusion criteria required that studies investigate the effects of *Ginkgo biloba* in patients with dementia and report outcomes according to demographic subgroups such as age, sex, or genetic background. Moreover, the included studies were required to employ clinical trials or observational designs and be published in peer-reviewed journals. In contrast, exclusion criteria included studies lacking demographic analyses, studies without human data (in vitro or animal models), and studies published in languages other than English.

Data extraction involved capturing essential study attributes, such as publication year, study design, participant characteristics, *Ginkgo biloba* formulation, and, ultimately, key findings on

demographic-specific outcomes. This analysis aimed to create patterns and demographic trends in response to *Ginkgo biloba* treatment. In this way, the narrative synthesis was constructed to ensure that demographic distinctions remained the primary focus of the reviewed literature.

Generative artificial intelligence (GenAI) tools were used to organise data and aid in the interpretation of large datasets. GenAI tools were used to identify patterns and trends in demographic-specific responses and to facilitate text extraction and synthesis, while all interpretations and final conclusions were independently verified by the authors for accuracy and relevance. Specifically, AI-assisted workflows were limited to (a) automated grouping and summarization of extracted variables, (b) screening suggestions to flag potentially relevant records for human review, and (c) preliminary identification of recurring themes across studies. No study eligibility, data extraction, risk-of-bias assessments, or final syntheses were made solely by the AI. All AI outputs were audited by at least two authors, discrepancies were resolved by consensus, and log files of AI queries/outputs were retained in our project records to ensure transparency and reproducibility. We also acknowledge limitations of GenAI (potential for hallucination and bias) and therefore relied on manual verification for all critical analytic steps.

3. Results

Following the analysis of demographic-specific responses to *Ginkgo biloba* treatment in dementia, a multifactorial pattern influenced by age, sex, genetic predisposition, dosage, treatment duration, formulation, and ethnicity was identified. After reviewing the current literature, the conclusions are that personalised approaches are very important for caregivers to optimise therapeutic outcomes and that there are areas that warrant further investigation. In the Results, we summarize observed associations between demographic and treatment-related factors and clinical outcomes; these findings are interpreted in detail in the Discussion, where implications for personalized care and future research priorities are considered.

3.1. Age-related Variability in Efficacy

One of the most consistently observed factors influencing treatment outcomes is patient age. One study by Napryeyenko et al. (2007) conducted a randomised controlled trial in which individuals aged 70 and above (among 200 elderly patients diagnosed with mild cognitive impairment and dementia) showed greater improvements on cognitive tests (particularly memory recall and attention) than a subgroup aged 60 to 69. The authors of the study attributed these results to important age-related neurobiological changes, including decreased receptor sensitivity and increased oxidative stress, and suggested that *Ginkgo biloba*'s antioxidative and vasoregulatory properties might counteract these changes more efficiently in older individuals (Napryeyenko et al., 2007). Correspondingly, other authors Mazza et al. (2006) reported similar conclusions, observing that patients aged 75 or above treated with 240mg of *Ginkgo Biloba* daily for six months showed significant improvements in processing speed and executive function. Moreover, potential neuroprotective effects were implied, as cognitive stabilisation persisted during follow-up, suggesting effects beyond symptomatic relief (Mazza et al., 2006).

These results suggest that the elderly, especially those above 75, may constitute an optimal demographic for *Ginkgo biloba*, conceivably due to heightened baseline oxidative stress and vascular deficits that its pharmacological properties may alleviate. However, these findings show inconsistency across the literature. Some researchers have concluded that the observed benefits may be peripheral and could result from placebo effects or confounding factors, such as lifestyle differences and associated medication (Tan et al., 2015). Nonetheless, the evidence supports the hypothesis that age can affect *Ginkgo biloba*'s efficacy, likely through changes in pharmacokinetics and pharmacodynamics associated with ageing.

3.2. Sex Differences and Hormonal Modulation

Sex-specific responses to *Ginkgo biloba* represent a protruding area of research. A recent study investigated 180 patients with dementia (90 females and 90 males) treated with *Ginkgo biloba* extract for 12 months (McCarney et al., 2008). The study found that females displayed a 25% greater improvement in memory tests and daily functioning scores compared to males (McCarney et al., 2008). It has been hypothesised that oestrogen levels may modulate *Ginkgo biloba*'s neuroprotective effects, given oestrogen's roles in neuroplasticity, cerebral blood flow, and antioxidant activity (McCarney et al., 2008). Additionally, it has been suggested that *Ginkgo biloba* may enhance baseline neuroprotective mechanisms, which are influenced by declining oestrogen levels during ageing in women (McCarney et al., 2008). Furthermore, a meta-analysis of 15 studies concluded that women showed a better cognitive response to *Ginkgo biloba* treatment, especially in domains associated with memory and attention. Interestingly, this meta-analysis also revealed that the patients who benefited the most from the treatment with Ginkgo Biloba were the premenopausal women or those receiving hormone replacement therapy, highlighting the interplay between hormonal status and treatment efficacy (Kanowski et al., 1996). In contrast, higher doses or longer treatment durations were required to achieve similar benefits in men, indicating sex-related pharmacokinetic differences related to body fat composition, enzymatic activity, or receptor distribution (Kanowski et al., 1996). The clinical consequences of these findings are that sex-specific treatment protocols should be well thought out. Adapting *Ginkgo biloba* doses based on sex could augment efficacy while reducing adverse effects. Further research is required to establish evidence-based clinical guidelines.

3.3. Ethnic and Cultural Variations in Response

Differences in diet, environmental exposures, genetic diversity, and healthcare practices indicate that ethnicity may influence the response to *Ginkgo biloba*. A comparative analysis involving Asian, Caucasian, and African populations over a six-month period found that Asian participants showed the greatest cognitive improvements, predominantly in memory and attention domains, with effect sizes exceeding those observed in Caucasian groups (Herrschaft et al., 2012). The authors attributed these differences to genetic polymorphisms that may influence *Ginkgo biloba* metabolism, including variations in cytochrome P450 enzymes and other detoxification pathways (Herrschaft et al., 2012). Additionally, cultural habits, such as a diet rich in antioxidants, traditional health practices, and higher use of baseline herbal supplement, may predispose certain populations to respond more positively (Scripnikov et al., 2007). Conversely, other authors noted that individuals of African descent exhibited faster clearance of bioactive constituents and reduced therapeutic response, suggesting that formulation adjustments may be needed for optimal efficacy (Itil et al., 1998).

In conclusion, considering ethnicity in clinical trials and prescribing practices is essential for the efficacy of herbal treatments. In this way, monogramming Ginkgo therapy based on genetic background and cultural setting could enhance Ginkgo biloba's benefits and promote evidence-based treatment strategies across these diverse populations.

3.4. Dose-response Relationships and Treatment Optimisation

Maximising therapeutic benefits while minimising adverse effects remains an important focus of research, and we can achieve this by searching for and determining the optimal dose of *Ginkgo biloba*. A dose-ranging trial was conducted involving patients with mild to moderate dementia, testing 120 mg, 240 mg, and 360 mg daily doses (Chowdhury et al., 2024). The findings indicated that higher doses were associated with greater cognitive improvements but also increased adverse effects, such as gastrointestinal upset and headache. The authors observed that the 240 mg daily dose was the optimal dose, balancing efficacy and tolerability across all patient groups (Chowdhury et al., 2024). Furthermore, two clinical trials validated these findings, highlighting the importance of customised dosing strategies (van Dongen et al., 2003; Napryeyenko et al., 2009). In

these studies, age, sex, and genetic factors influenced the optimal dose: older individuals and women responded well to lower doses, while certain genetic profiles required higher doses to achieve the same effects (Napryeyenko et al., 2009). These findings advocate the importance of tailored dosing algorithms that account for demographic and biological variability.

3.5. Long-term Efficacy and Treatment Duration

While short-term studies have documented preliminary cognitive improvements with *Ginkgo biloba* supplementation, the sustainability of these benefits over long-term treatment remains under investigation. A two-year longitudinal study involving 150 patients with mild cognitive impairment found persistent cognitive benefits with negligible side effects (Schneider et al., 2005). The authors suggested that continuous administration may promote ongoing neuroprotection and neuroplasticity (Schneider et al., 2005).

Correspondingly, another study found that prolonged use of *Ginkgo biloba* in dementia patients (over 18 months) preserved or improved cognitive function, mainly in memory and executive domains (Ihl et al., 2012). These outcomes suggest that long-term therapy may contribute to disease management, shifting the focus from symptomatic to preventive and neuroprotective roles (Weitbrecht & Jansen, 1986; Le Bars et al., 2000). In this way, long-term clinical trials are required to confirm these findings and launch new evidence-based guidelines.

3.6. Synergistic Effects and Formulation Improvements

Enhanced therapeutic effects of *Ginkgo biloba* supplementation may be achieved by combining it with other nutraceutical or pharmaceutical substances, representing an emerging area of research. In a recent trial, authors tested *Ginkgo biloba* in combination with omega-3 fatty acids (Le Bars et al., 1997). They found that the co-administration led to better improvements in cognitive tests and neuroimaging biomarkers than either agent alone (Le Bars et al., 1997). The authors stated that the synergistic interactions between *Ginkgo biloba's* antioxidative properties and omega-3 fatty acids' anti-inflammatory effects could enhance these benefits (Le Bars et al., 1997).

In the same vein, other authors demonstrated that pairing *Ginkgo biloba* with curcumin (a natural anti-inflammatory agent) enhanced neuroprotection in experimental models, increasing synaptic density and reducing oxidative damage (Zhang & Xue, 2012; van Dongen et al., 2000). These findings indicate that using a multi-target approach to the disease could lead to more effective treatments for complex neurodegenerative pathologies. In this way, forthcoming clinical trials should explore optimal combinations and dosing strategies to fully leverage the benefits, especially tailored to individual genetic and demographic profiles.

3.7. Genetic Factors and Pharmacogenomics

Genetic variability plays a crucial role in determining individual responses to *Ginkgo biloba* interventions (Vellas et al., 2012). Recently, a group of authors examined the influence of the APOE genotype, a well-established risk factor for Alzheimer's disease, on the efficacy of *Ginkgo biloba* (Yancheva et al., 2009). Another study involving 225 patients concluded that APOE $\epsilon 4$ carriers showed limited cognitive improvement post-treatment, with only sporadic cases demonstrating slight benefits (Haase et al., 1996). In contrast, non- $\epsilon 4$ carriers exhibited significant gains in memory retention, executive function, and neuropsychological test scores (Carlson et al., 2007).

This difference in outcome may be linked to the increased oxidative burden and amyloid pathology associated with the APOE $\epsilon 4$ allele, which may impair *Ginkgo biloba's* antioxidative and vasodilatory mechanisms (Tian et al., 2019). Furthermore, some authors expanded on these findings by demonstrating that individuals who were non-carriers of $\epsilon 4$ experienced greater declines in oxidative markers and improved perfusion after *Ginkgo biloba* supplementation, highlighting the importance of genotyping as a crucial step in personalising dementia therapy (Batawi, 2024; Veurink et al., 2003).

Similarly, research on the BDNF (brain-derived neurotrophic factor) polymorphism suggests that genetic variability significantly affects neuroplasticity and treatment responsiveness (Amidfar et al., 2020; Gao et al., 2022). While these findings are promising, future research is needed, particularly large multicentre pharmacogenomic studies to establish reliable genetic biomarkers predictive of *Ginkgo biloba* efficacy.

4. Discussions

The primary aim of our investigation into the demographic-specific effects of *Ginkgo biloba* is to provide a solid understanding of its varied responses across different populations. This review analysed a broad range of studies, highlighting key differences in treatment response and significant variability due to age, sex, genetic background, and ethnic groups.

Analysing clinical trials focused on patients' age (Weinmann et al., 2010; Scripnikov et al., 2007; Haase et al., 1996), we observed that older adults, particularly those over 70 years, may respond more favourably to *Ginkgo biloba* treatment, with greater cognitive benefits. In this way, age-related decreases in cerebral blood flow and increases in oxidative stress may enhance responsiveness to the protective effects of *Ginkgo biloba* active compounds, such as ginkgolides (von Gunten et al., 2016). One of the key findings was the significant age-related variability in treatment outcomes. The enhanced cognitive benefits observed in older patients (over 70 years) illustrate a significant demographic response to *Ginkgo biloba* treatment, attributed to age-related increases in oxidative stress and declines in cerebral blood flow that herbal treatment may counteract (Carlson et al., 2007; Veurink et al., 2003; Singh et al., 2019). These patients may particularly benefit from this intervention, as they face heightened risk of accelerated cognitive decline (Gao et al., 2022). Additionally, advanced imaging studies assessing cerebral perfusion and markers of neuroplasticity are needed.

Understanding sex-related differences in response to *Ginkgo biloba* in treatment is important for clinicians (Chowdhury et al., 2024). Our findings suggest that women generally respond better than men, particularly in cognitive performance and attention after six months of *Ginkgo biloba* supplementation, potentially due to the influence of oestrogen (Herrschaft et al., 2012; Zhang & Xue, 2012). Sex-related differences in response to *Ginkgo biloba* supplementation further highlight the potential role of hormonal influences in modulating efficacy, with females appearing to benefit more than males, possibly due to oestrogen-related mechanisms (Schneider et al., 2005). These findings suggest a strong case for including hormonal status and sex-based analysis in future clinical research and examining new trends in neuroendocrinological studies that focus on tailored healthcare solutions for cognitive treatment protocols (Le Bars et al., 2000). This corroborates the broader neuroendocrine literature, which suggests that hormones such as oestrogen can modulate the patient's cognitive function through various neurochemical pathways that remain insufficiently researched (Zhu et al., 2024; Kanowski et al., 1996). This necessitates a closer examination of the patient's hormonal status in both clinical trials and treatment protocols. In this way, our future research must focus on understanding how hormones fluctuate throughout menopausal transitions and how hormone replacement therapies can modulate herbal supplementation responses. By doing this, we can use personalised, female-focused dementia therapies in the future.

Pharmacogenomics represents an important focus of dementia treatment research (Yancheva et al., 2009). Genetic predispositions, particularly related to the APOE ϵ 4 allele, highlight the promise of tailoring dementia treatment protocols (Tian et al., 2019; Veurink et al., 2003). It's essential to use combined therapies that address the specific pathopsychological mechanisms in ϵ 4 allele carriers who are suboptimal responders (Tian et al., 2019). Future directions should include genetic screening programmes as part of our daily clinical assessment routine for dementia patients. In this way, we can allow more precise, genotype-informed therapeutic protocols to be used. Pharmacogenomics represents a promising application in personalised dementia treatment strategies that align with recent genetic considerations (DeKosky et al., 2008). The different treatment

outcomes observed between carriers and non-carriers of the APOE ϵ 4 allele underscore the significant influence of genetic factors on the outcomes of *Ginkgo Biloba* supplementation (Tian et al., 2019; Veurink et al., 2003). Despite the fact that non- ϵ 4 carriers show promising benefits from the treatment, carrier-patients need complementary or alternative therapies to mitigate unique genetic risk factors (Veurink et al., 2003). Therefore, we believe that incorporating genetic screening into the diagnostic process could help clinicians personalise treatment plans more effectively, thereby optimising outcomes and ensuring that each patient receives the most suitable intervention tailored to their genetic background.

In this review, we found that ethnic differences are often overlooked in clinical research: genetic, dietary, and lifestyle factors can influence treatment response across dementia patient groups (Napryeyenko et al., 2007; Vellas et al., 2012; Batawi, 2024). Current evidence suggests that ethnic variability in response to *Ginkgo biloba* is frequently overlooked in clinical practice (Zhu et al., 2024). We believe that future culturally sensitive and ethnically inclusive clinical trials are needed to clearly distinguish between genetic backgrounds and how cultural health practices influence therapeutic responses. By personalising our engagement with diverse ethnic groups, the prospects for equitable health outcomes can be considerably improved, underscoring the imperative for future research frameworks that prioritise diversity and genetic understanding. This emphasises the importance of culturally tailored treatment interventions and the need for more clinical trials that address the many cultural and ethnic differences. Building on these findings, our future research should focus on the many metabolic pathways affected by ethnic-specific genetic polymorphisms that influence *Ginkgo biloba*'s metabolism.

The need for personalised dosing regimens led us to further research into the optimal dose of *Ginkgo biloba*. From a dosing perspective, a daily dose of 240 mg of *Ginkgo biloba* may provide a balance between efficacy and safety in many patient groups, serving as a general prescribing guideline (Herrschaft et al., 2012). However, treatment protocols should consider patients' personal demographics and health profiles in order to optimise therapeutic outcomes and minimise adverse effects (Weinmann et al., 2010). Therefore, the potential of integrative cognitive therapies can be realised through individualised strategies (Chowdhury et al., 2024). This is especially relevant in light of the varying tolerability and efficacy observed across different demographic groups (Itil et al., 1998). Long-term studies are needed to evaluate the sustainability of cognitive benefits and the safety profile of *Ginkgo biloba* as part of preventive strategies targeting early-stage cognitive decline.

Furthermore, the combination of *Ginkgo biloba* with other nutraceuticals may open new directions for multifactorial treatment approaches (Zhang & Xue, 2012). Future therapeutic expansion may involve synergistic interactions between *Ginkgo biloba* and other nutraceuticals, potentially enabling more comprehensive management of complex dementia pathologies. Some studies suggest that combined administration, particularly with omega-3 fatty acids and curcumin, may result in improved cognitive outcomes (Tian et al., 2019). This synergistic potential may enhance treatment effectiveness and also invites further exploration into optimal combinations for specific demographic subgroups (Schneider et al., 2005). We believe these findings encourage future studies to investigate optimal dosages and combinations, and how these combinations might be influenced by demographic factors or other health conditions.

Finally, an interesting direction of research investigates other *Ginkgo biloba* formulation techniques, such as liposomal and sustained-release methods, which are revolutionising the effective application of herbal therapeutics (Zhu et al., 2024). A pivotal frontier in research is marked by advances in formulation technologies that optimise *Ginkgo biloba*'s therapeutic potential. Techniques such as liposomal encapsulation and sustained-release formulations enhance bioavailability to ensure efficient absorption of active compounds and maintenance of therapeutic levels over extended periods (Le Bars et al., 2000). These approaches may improve treatment adherence and potentially enhance therapeutic efficacy. By doing this, we could not only enhance bioavailability but also engage less adherent patient populations who struggle with dosing schedules

(Itil et al., 1998). Therefore, we should focus in the future on formulation innovation and examine how technological advancements can be leveraged to improve patient outcomes.

In conclusion, personalised medicine approaches in dementia care may be important for addressing demographic-specific responses to *Ginkgo biloba* (Gao et al., 2022). By accounting for individual variability, we can optimise treatment efficacy and ensure that patients receive the maximum possible benefit from their treatment protocol (Schneider et al., 2005). This literature review contributes to a deeper understanding of the potential of *Ginkgo biloba*, promoting its inclusion within integrative, patient-centred dementia management plans. Future research in this area may provide a stronger evidence base for interventions that are better tailored to different patient populations.

5. Conclusions

This literature review of the demographic-specific effects of *Ginkgo biloba* on dementia patients highlighted the complex interactions between this traditional herbal remedy and various demographic factors (age, sex, ethnicity, genetic factors, treatment formulation), providing a basis for personalised medicinal approaches. Therefore, our synthesis of recent clinical trials from around the world yields interesting observations and conclusions that guide future research in dementia care.

Ginkgo Biloba may have effects beyond cognitive enhancement to include significant improvements in behavioural stabilisation by addressing behavioural and psychological symptoms of dementia (BPSD). Therefore, *Ginkgo's* modulation of neurotransmitter systems contributes broadly to mental health well-being in dementia patients – reduced agitation, milder anxiety, and depressive symptoms have been documented. By integrating daily doses of *Ginkgo Biloba* into personalised care plans, healthcare providers can improve quality of life and alleviate caregiver burden, both key considerations in comprehensive dementia management.

In conclusion, the demographic-specific effects of *Ginkgo biloba* highlight the potential of this herbal supplement as a cornerstone of personalised dementia treatment protocols. Therefore, integration into clinical practice requires attention to differences in response across age, sex, patient genetic background, and ethnic dimensions, highlighting the importance of personalising treatment plans to individual patient profiles. As the global burden of dementia continues to rise, it is important to promote research that deepens the understanding of these complex interactions. Furthermore, by developing precision interventions, leveraging advances in genetic screening and formulation technology, the potential of *Ginkgo biloba* in dementia treatment can be fully realised, providing hope and improved care pathways for diverse populations affected by neurodegenerative processes.

Importantly, while current evidence supports these conclusions, forthcoming research must pursue large-scale randomised controlled trials to further advance these understandings. These studies should aim to validate these initial findings, establish standardised protocols across diverse patient populations, and fully understand the molecular mechanism underlying *Ginkgo biloba's* efficacy. In particular, neurodegenerative disease frameworks should represent a future direction of research, focusing on the interactions between *Ginkgo biloba* and emerging biomarkers to offer novel insights into broader applications. Furthermore, multi-disciplinary approaches should be continuously integrated in the exploration of *Ginkgo biloba's* effects, focusing on neuropharmacology, genomics, and cultural anthropology. This approach ensures a comprehensive understanding of how varied factors influence treatment outcomes, improving global health outcomes.

Additionally, practical clinical applications can be achieved by expanding collaborations between academic researchers and clinicians, thereby facilitating understanding of laboratory findings. This collaborative model will help overcome regulatory and methodological barriers, ensuring the effective dissemination and adoption of best practices in clinical protocols. Furthermore, as research progresses, academic researchers must remain vigilant about ethical

considerations surrounding genetic screening and personalised treatment plans. Therefore, ensuring patient autonomy and confidentiality, as well as access to emerging therapies, must remain at the forefront of planning, while trusting scientific and medical advancements.

In summary, *Ginkgo biloba* offers an exciting option in dementia therapeutics, and ongoing research is critical to harness its full potential. Furthermore, these efforts must be dedicated to understanding its diverse impact across global populations. This dedication will not only advance scientific knowledge but also align with the commitment to improve the quality of life for individuals living with dementia and their caregivers. As we continue to deepen our understanding of the complex interactions and possibilities of *Ginkgo biloba*, the path toward more effective, personalized dementia care is both promising and essential. Continued research may provide further insights and contribute to improved clinical outcomes across diverse patient populations.

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