Assessing the Spatiotemporal Dynamic of Global Grassland Carbon Use Efficiency in Response to Climate Change from 2000 to 2013

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Abstract: The carbon use efficiency (CUE) of grassland, a ratio of net primary production (NPP) to gross primary productivity (GPP), is an important index representing the capacity of plants to transfer carbon from the atmosphere to terrestrial biomass. In this study, we used the Moderate Resolution Imaging Spectroradiometer (MODIS) data to calculate the global grassland CUE, and explore the spatiotemporal dynamic of global grassland CUE from 2000 to 2013 to discuss the response to climate variations. The results showed that the average annual CUE of different grassland types follows an order of: open shrublands > non-woody grasslands > closed shrublands > woody savannas > savannas. The higher grassland CUE mainly occurred in the regions with cold and dry climate. By contrast, the regions with the lower grassland CUE were mostly in warm and wet environments. Moreover, the CUE exhibited a globally positive correlation with precipitation and a negative correlation with temperature. Therefore, the grassland CUE has considerable spatial variation associated with grassland type, geographical location and climate change.

Keywords: Global grassland ecosystems; Carbon use efficiency (CUE); Net primary production (NPP); Gross primary productivity (GPP); Precipitation; Temperature.

Introduction

Grassland, one of the largest types of vegetation in the world, accounts for nearly 25% of the global land surface. Grassland ecosystem plays a significant role in maintaining material circulation and balancing greenhouse gas, particularly in terms of global carbon storage and further carbon sequestration (O'Mara 2012; Scurlock and Hall 1998). The carbon use efficiency (CUE) is an important indicator to measure how efficiently a grassland sequesters atmospheric carbon (Delucia et al. 2007; Gifford 2003), and may be a critical control on carbon storage in ecosystems (Allison et al. 2010; Ise et al. 2010; Manzoni et al. 2011). The CUE refers to the ratio of net primary productivity (NPP) to gross primary productivity (GPP). GPP is the total mass of C assimilated by the photosynthesis, which represents the capacity of plant to capture

energy and carbon. NPP is the net carbon stored as new plant material in an ecosystem which is the amount of C stored following the loss of C from GPP through autotrophic respiration (Chapin et al. 2002; Kwon and Larsen 2012). A better understanding of how grassland CUE varies in relation to climate change factors can have the potential to advance global carbon sequestration accounting and improve the global change research.

Many studies have assumed a constant value of CUE among different species (Running and Coughlan 1988), and different ecosystem types (Gifford 1994; Gifford 1995; Landsberg and Waring 1997; Ryan and Hubbard 1994). Furthermore, the CUE remains constant across a range of temperatures and CO₂ levels for herbaceous and woody plants (Cheng et al. 2000; Dewar et al. 1999). A study made by Zha et al. (2013) of 18 sites in Canada's temperate and southern boreal forests shows that the aboveground CUE ratio is relatively constant (0.29 ± 0.06), with no consistent differences among species or age classes. Waring et al. (1998) suggested that a constant value of 0.47 was appropriate for most forest. Many ecosystem process models such as FOREST-BGC (Running and Coughlan 1988) and CASA (Potter et al. 1993) assumed a constant CUE in quantifying plant respiration.

However, the assumption that the CUE ratio is constant has been tested only in a limited way as it ignores the impacts of factors such as species, environment and age on CUE, it is doubtful and controversial that the principle is globally applicable (Chapin et al. 2002; Delucia et al. 2007; Dewar et al. 1999; Xiao et al. 2003). These researches have suggested a variable CUE among different ecosystems, vegetation types and species (Amthor 2000; Delucia et al. 2007; Iersel 2003; Ryan et al. 1997; Zhang et al. 2009). Piao et al. (2010) found that CUE in tropical zone was quite different from that in south temperate zone. Research using field-based data and remote sensing data made by Kwon and Larsen (2012) in the eastern USA has indicated that the forest CUE significantly changes with forest type, climate and geographic location. A study made by Street et al. (2013) in European subarctic shows that the CUE of bryophyte is higher than vascular plant.

As we can see from the previous researches, most of the studies on CUE research mainly discuss a few ecosystem types and focus on the stand or site levels (Campioli et al. 2011; Iersel 2003; Metcalfe et al. 2010; Smith and Dukes 2012). The spatial and temporal dynamics of the grassland CUE have rarely been explored at the global scale. It is essential to discover how the ongoing climate variation affects the CUE of grassland ecosystems at the global scale.

Remote sensing has been used to calculate the CUE at the regional and global scale (Kwon and Larsen 2012; Nemani et al. 2003; Zhao et al. 2006). Moderate Resolution Imaging Spectroradiometer (MODIS) products of GPP and NPP were monitored by using the remote sensing at the global scale, and these data provided a unique opportunity for calculating the value of global CUE. There is a fairly strong correlation between the MODIS GPP and ground flux tower-based GPP ($r^2 = 0.737$). And the resulting MODIS NPP data is consistent with the field-observed NPP estimation ($r^2 = 0.80$). These products are one of the most reliable data sources at the global scale (Heinsch et al. 2006; Zhao et al. 2005). Zhang et al. (2009); Zhang et al.

(2014) explored the spatial pattern of the global CUE and its relationship with climate factors using the MODIS GPP and NPP data. By comparing the CUE calculated by the field-based forest inventory and analysis (FIA) data and MODIS data, the result supported the use of the more easily obtained MODIS CUE (Kwon and Larsen 2012) in research. Therefore, we used the MODIS GPP and NPP data to calculate the global grassland CUE in this study.

The objectives of this study are to: (1) explore the spatial and temporal dynamics of the global grassland CUE during the period 2000-2013; (2) compare the CUE ratio responses to climate variations among different grassland types; (3) investigate the correlations between the grassland CUE and the climatic factors to reflect how the climate factors affect grassland carbon cycles. These findings not only contribute to analysis of carbon sources or carbon sinks of grassland ecosystem, but also have great significance to predict the effect of global change and human disturbance on global grassland carbon balance.

Materials and Methods

MODIS GPP data

Annual MODIS GPP data (1 km resolution) from 2000 to 2013 were obtained from the Numerical Terradynamic Simulation Group (NTSG) at the University of Montana (<http://www.ntsg.umn.edu/>). These datasets are in TIFF format and the WGS84 geographic coordinate system, and were converted into a grid format by using ArcGIS software (ESRI, California, USA).

The latest Collection 5 (MOD17) MODIS GPP values are calculated as follows:

$$GPP = \varepsilon \times PAR \times FPAR \quad (1)$$

$$PAR = 0.45 \times SWrad \quad (2)$$

$$\varepsilon = \varepsilon_{max} \times T_f \times VPD_f \quad (3)$$

where ε is the light use efficiency parameter; ε_{max} is the max radiation use conversion efficiency of the vegetation; and VPD_f and T_f are the reduction scalars from water stresses (high daily vapour pressure deficit) and low temperature (low daily minimum temperature T_{min}), respectively. PAR is the downward photosynthetically active radiation; $SWrad$ is the short-wave downward solar radiation, of which 45% is photosynthetically active radiation (PAR); FPAR is the fraction of incident PAR that is absorbed by the canopy. The FPAR is determined using remote sensing MODIS and ε_{max} is determined based on the theory of Monteith (1972) for each biome. PAR, $SWrad$, VPD_f and T_f are determined from meteorological field data. Each parameter value is obtained from the Biome Parameter Look-Up Table, which contains parameters for specific leaf area and respiration coefficients for representative vegetation in each biome type (Running et al. 2000; White et al. 2000a). The GPP product has been validated by comparison with data from 250 global eddy flux towers,

and the results showed strong correlations between the modelled GPP and the site-derived GPP data (Heinsch et al. 2006).

MODIS NPP data

NPP is estimated from the global NPP product MOD17A3 (1 km spatial resolution), which was obtained from the NASA MODIS Land Science team website (<http://landval.gsfc.nasa.gov/>). NPP is calculated as the difference between GPP and respiration, which includes both maintenance and growth components. The newly developed NPP is calculated as follows:

$$NPP = \sum_{1}^{365} GPP - R_{m_lr} - R_{m_w} - R_g \quad (4)$$

where R_{m_lr} refers to the maintenance respiration from living leaves and fine roots. R_{m_w} is the annual maintenance respiration of live cells in woody tissue, and R_g is the annual growth respiration. More detailed descriptions on the methods used for modelling MODIS NPP can be found in related publications (Heinsch et al. 2006; Zhao et al. 2004).

The NPP product was validated using the Ecosystem Model-Data Intercomparison (EMDI) NPP data set (Fig.1), which is composed of 2523 sites that represent the majority of global biomes (Olson et al. 2001). The validation results showed that the modelled NPP results agree well with field NPP data.

Fig.1 Comparison of MODIS mean annual NPP with the EMDI NPP data set.
(The solid line is a slope of 1.0, and the dashed line is the regression line.)

Land cover data and climate factors data

To be consistent with the GPP and NPP results, we used land cover data from the MOD12Q1 product. In the global land cover map, the classes are defined according to the International Geosphere-Biosphere Project (IGBP) land cover system, which were based on satellite imagery of land cover and vegetation type (Loveland et al. 2000). The primary land cover scheme identifies 17 classes defined by the IGBP, including 11

natural vegetation classes, 3 human-altered classes, and 3 non-vegetated classes. It was used with the 1-km resolution MOD12Q1 product (land cover type 1 in the MOD12Q1 data sets). The grassland cover categories used in this study include closed shrublands, open shrublands, woody savannas, savannas and non-woody grasslands shown in Table 1 (White et al. 2000b). All files of land cover data were merged together and converted into TIFF format using the MODIS reprojection tool, and then converted into grid format to match the NPP and GPP data.

Table 1. The description of the grassland types in IGBP class scheme

Grassland types	Description
Closed Shrublands	Lands with woody vegetation with a height less than 2 meters. The total percent cover, including the herbaceous understory, exceeds 60%. The shrub foliage can be either evergreen or deciduous.
Open Shrublands	Lands with woody vegetation with a height less than 2 meters, and sparse herbaceous understory. Total percent cover is less than 60%. The shrub foliage can be either evergreen or deciduous.
Woody Savannas	Lands with and herbaceous understory, typically graminoids, and with tree and shrub cover between 30-60%. The tree and shrub cover height exceeds 2 meters.
Savannas	Lands with an herbaceous understory, typically graminoids, and with tree and shrub cover between 10-30%. The tree and shrub cover height exceeds 2 meters.
Non-woody Grasslands	Lands with herbaceous types of cover, typically graminoids. Tree and shrub cover is less than 10%.

Climate data (temperature and precipitation) from 2000 to 2013 were obtained from the Climate Research Unit data (Harris et al. 2014). This new dataset CRU_TS_3.22 was provided by the British Atmospheric Data Centre, extending from 1901 to 2013. Mean annual temperature (MAT) and mean annual precipitation (MAP) were incorporated from the monthly data. The annual average temperature and precipitation were calculated from the monthly data by using ArcGIS V10.0 (ESRI, California, USA).

Analysis of grassland CUE dynamics

Simple linear regression was employed to analyze the inter-annual variation of grassland CUE dynamics at a global scale from 2000 to 2013. The slope of the trend line in the multiyear regression equation for a single pixel represents the inter-annual variation rate, which is solved by the ordinary least-squares method. If Slope is positive, it indicates an increasing trend of grassland CUE, whereas a negative slope value indicates a decreasing trend (Yang et al. 2016).

The significance of the variation tendency in our study was determined by using the statistic F-test to represent the confidence level of variation. Through the significance test ($P < 0.01$ or $P < 0.05$), the correlation coefficient can indicate whether the trend is “extremely significant” or “significant”. The significance levels of F were classified

into six levels: extremely significant decrease (ESD, $F_{\text{slope}} < 0$, $P < 0.01$), significant decrease (SD, $F_{\text{slope}} < 0$, $0.01 < P < 0.05$), non-significant decrease (NSD, $F_{\text{slope}} < 0$, $P > 0.05$), non-significant increase (NSI, $F_{\text{slope}} > 0$, $P > 0.05$), significant increase (SI, $F_{\text{slope}} > 0$, $0.01 < P < 0.05$) and extremely significant increase (ESI, $F_{\text{slope}} > 0$, $P < 0.01$).

In addition, the temporal dynamics of the grassland CUE for each grassland type from 2000 to 2013 were explored, their annual mean values were plotted against time, and the linear trend was calculated to indicate the annual changing trend.

Correlation analysis between grassland CUE and climate factors

The Pearson correlation coefficients between grassland CUE and mean annual precipitation (MAP), and mean annual temperature (MAT) were calculated to reflect the sensitivity of grassland CUE to climate variables (Gang et al. 2016).

If the correlation coefficient passes the significance test, then an extremely significant ($P < 0.01$) or significant ($P < 0.05$) linear correlation is indicated. The significance levels of correlation coefficients were classified into six levels: extremely significant negative (ESN), significant negative (SN), non-significant negative (NSN), non-significant positive (NSP), significant positive (SP) and extremely significant positive (ESP).

Results

Temporal and spatial variation of the grassland CUE

The spatial distribution of the global grassland carbon use efficiency from 2000 to 2013 are presented in Fig.2. The higher grassland CUE mainly occurred in the northern Canada, western South America, northern Russia, central Asia, South Africa and southwest Australia, where the feature of climate is cold and dry with low precipitation. By contrast, the regions with the lower grassland CUE were mostly in the northeast of Brazilian Plateau, West Africa, southern Asia and northwest of Australia. In general, the CUE is high in cold and dry regions and low in wet, warm regions with abundant precipitation.

Fig.2 Spatial pattern of the average global carbon use efficiency (CUE)

The Mann-Kendall test was performed in the CUE trend analysis during the 2000-2013 period (Table 2). The CUE exhibits a slightly increasing trend on the whole grassland. The detail of the grassland CUE variation trend is shown in Fig.3. The higher increase of the grassland CUE mainly occurred in the northeast of the Brazilian Plateau and the north of the Congo Basin. By contrast, the regions with higher decrease of the grassland CUE were mostly in southern Africa and northwest of Australia. The CUE globally increased in nearly 54.96% of regions vegetated by grassland ecosystems from 2000 to 2013 (Fig.4). Furthermore, the regions that experienced a significant increase of the grassland CUE at 95% confidence level accounted for 6.42% of the total grassland areas. And 5.28% of the regions experienced an extremely significant CUE increase at 99% confidence level. These regions were mainly distributed in north of the Congo Basin, Chad Basin, northeast of the Brazilian Plateau, Qinghai-Tibetan Plateau and northeast of Australia. The regions that experienced a non-significant decrease of the grassland CUE were mainly in Australia, Turan Plain and southern Africa. The regions that showed significant and extremely significant decreases at 95% and 99% confidence levels, respectively, occupied 4.33% and 2.38% of the grassland areas. The regions were mainly localized in the west of Kazakhstan and northwest of the South Africa.

Table 2. Mann-Kendall test of CUE change trend

Carbon use efficiency (CUE)	
Slope	0.0002
R ²	0.0263
Z value	0.3285

Fig.3 Spatial pattern of the global grassland carbon use efficiency (CUE) trend from 2000 to 2013

Fig.4 Spatial pattern of the global carbon use efficiency (CUE) significance tests of the trend from 2000 to 2013

Temporal dynamics of the grassland CUE for each grassland type

The annual variation of the grassland CUE had been plotted against time (Fig.5). The highest CUE at a global scale was in the open shrublands with an annual mean value of 0.562, whereas the least CUE was found in the savannas (0.478). From the Fig.6, we can find that most of the savannas distributed in wet and warm regions, whereas the open shrublands located in the dry and cold regions. In general, the value of CUE showed a significant difference among grassland ecosystems. The average annual CUE of each grassland type followed an order of: open shrublands (0.562) > non-woody grasslands (0.549) > closed shrublands (0.548) > woody savannas (0.542) > savannas (0.478). And the grassland types distributed in warm and wet environments had a lower CUE than the other types located in relatively cold and dry regions.

Increased CUE was observed in the savannas and woody savannas during the 2000-2013 period. By contrast, decreased CUE was observed in the closed shrublands, open shrublands and non-woody grasslands. Noticeably, the annual variation of all grassland types occurred in similar trend from 2000 to 2007. During the 2007-2010 period, the CUE of non-woody grasslands showed an opposite trend with open shrublands and closed shrublands. Then the CUE of all grassland types shared the similar changing trend with a general decreasing trend from 2010 to 2013.

Fig.5 Temporal dynamics of grassland carbon use efficiency (CUE) from 2000 to 2013 for each grassland type

Fig.6 The spatial distribution of grassland ecosystems

Correlations between the grassland CUE and climate factors

In order to discover how the ongoing climate factors are affecting carbon cycles in grassland ecosystems, we discussed the correlations between the grassland CUE and climate factors. Nearly 55% of the regions vegetated by grassland ecosystems experienced rising precipitation from 2000 to 2013 (Fig.7a). The regions presenting a decreased mean annual precipitation (MAP) were mainly distributed in the south of North America and South America, mid-west of Australia, and central Asia. The mean annual temperature (MAT) increased in nearly 60% of the regions of grassland ecosystems, especially in northern Eurasia (Fig.7b). The regions that showed a decreased MAT were mainly located in the Alaska, Scandinavian Peninsula, middle and east of Australia, and central Eurasia.

Fig.7 Spatial pattern of the mean annual precipitation (MAP) (a) and mean annual temperature (MAT) (b) trends from 2000 to 2013

The spatial distributions of the correlations between the MAP/MAT and the grassland CUE at different significance levels are presented in Fig.8 and Fig.9. Based on the two figures, the result showed that the significant correlations between the grassland CUE and the MAT were 24.53%, larger than those of the grassland CUE and the MAP (16.18%). This result indicated that the CUE was more sensitive to temperature than precipitation. Most of the grassland areas showed non-significant correlations between the grassland CUE and the MAT or MAP during the entire study period. The significant positive correlations (including 95% and 99% confidence level) between the grassland CUE and the MAP were 14.32%, these regions were mainly distributed in the Australia, Ethiopian Plateau, south of the Africa, America, Eurasia, Turan Plain, north of the Brazilian Plateau (Fig.8). By contrast, the significant negative correlation between the grassland CUE and the MAP were 1.85%. The regions that displayed a significant negative correlation (including 95% and 99% confidence level) between the grassland CUE and the MAT (15.79%) were mostly located in the Australia, East African Plateau, the Mississippi plain (Fig.9).

Fig.8 Correlations between grassland carbon use efficiency (CUE) and MAP during the 2000-2013 period

Fig.9 Correlations between grassland carbon use efficiency (CUE) and MAT during the 2000-2013 period

Discussion

Understanding the spatial and temporal variability of the grassland CUE, and the responses of the CUE to climate variations at a global scale is essential for improving our knowledge of global terrestrial carbon cycling (Delucia et al. 2007; Zhang et al. 2014). The application of remote sensing data (e.g. MODIS GPP and NPP) that are high-resolution and continuous in both the spatial and temporal dimensions, has made it possible to estimate the patterns of spatiotemporal variation in the grassland CUE at a global scale.

This study found that the grassland CUE ranged between 0.478 of the savannas and 0.562 of the open shrublands with an average of 0.536 during the period of 2000-2013. This result was within the ranges of Iersel (2003), which speculated that the range of herbage CUE should range between 0.68 and 0.20, and was consistent with study of Amthor (2000), who concluded that the CUE should vary between 0.2 and 0.65. And the grassland CUE differed among of grassland types, which further confirms that the

CUE is not a constant. This result was consistent with previous studies, which pointed out that the CUE was different among of the ecosystems and species (Amthor 2000; Delucia et al. 2007; Iersel 2003; Zhang et al. 2009).

From the global distribution of grassland CUE, we can see the higher grassland CUE mainly occurred in the regions with cold and dry climate. By contrast, the regions with the lower grassland CUE were mostly in warm and wet environments. These results were similar to those found in other study (Kwon and Larsen 2012; Zhang et al. 2009; Zhang et al. 2014). Zhang et al. (2014) found the CUE is high in cold and dry regions and low in warm regions with abundant precipitation. The forest research in the USA (Kwon and Larsen 2012) showed that the highest CUE values were clustered in the northwest of the study area with low temperature and precipitation. The lowest CUE value were in Louisiana and Mississippi with higher temperature and precipitation. The CUE in warm and wet regions was lower due to the relatively high plant respiration and long growing season (Delucia et al. 2007). The vegetation in cold and dry regions consumed less energy to support standing biomass than those in warm and wet regions, therefore they had higher carbon storage efficiency (Cannell 1989; Ryan and Hubbard 1994; Teskey et al. 1995).

Furthermore, the extremely significant decrease of the grassland CUE mainly distributed in the west of Kazakhstan and northwest of the South Africa, which were vegetated by the open shrublands and non-woody grasslands, had experienced increasing temperature and decreased precipitation. According to the study of (Propastin et al. 2012), the decreased precipitation and high temperature raise respiration rate, which considerably decrease the carbon sequestration by grass vegetation. In the Australia, the decrease of the grassland CUE mainly located in the western regions, which had experienced increasing temperature and decreasing precipitation. By contrast, the increase of grassland CUE mostly concentrated in the eastern regions, which had an opposite trend of precipitation and temperature. These findings indicated a negative correlation between the CUE and temperature, a positive correlation between the CUE and precipitation. This result was similar to those found in other studies (Delucia et al. 2007; Ryan et al. 1996; Zhang et al. 2014).

The temperature variation affected the photosynthesis and respiration rate, thus resulted in the change of CUE (Giardina et al. 2003). And the sensibility of respiration to increased temperature is higher than to the GPP (Curtis et al. 2005). Ryan and Hubbard (1994) concluded that the decrease in CUE with increased temperature is due to higher energy requirements to maintain living tissue, which results in the rate of respiration increasing exponentially with temperature. However, in Tibetan Plateau, Yunnan-Guizhou Plateau and Central Siberian Highlands, the grassland CUE increased with rising temperature. Many studies have confirmed that the respiration of vegetation has temperature acclimation phenomenon in the regions with lower temperature (Atkin et al. 2000; Bostad et al. 2003; Gifford 2003), the plant respiration rate declined rapidly with the increased temperature. In frigid region, the plant growth was limited by the short growing season, rising temperature along with the extension of growing season may led to the significant increase of vegetation GPP (Piao et al. 2007), whereas the increase of the consumption of plant respiration was relatively low

as the temperature acclimation (Atkin et al. 2000; Maseyk et al. 2008).

The positive correlation between the vegetation CUE and precipitation had been reported in other related studies (Metcalf et al. 2010; Smith and Dukes 2012; Zhang et al. 2014). Vegetation responds to water loss in many ways including changing the water use strategy and increasing water uptake from soil in arid and semi-arid regions (Hsiao 1973; Waring and Running 2007). The decrease of available water would increase physiological stress and lead to the slowing of water or nutrient supply to seedlings and the decrease of leaf growth rate. Consequently, the rate of photosynthesis decreased (McDonald et al. 1986). The study of Metcalfe et al. (2010) in Amazon rainforest found that the decreased precipitation led to the increase of total ecosystem respiration and more proportion of energy required to be allocated to respiratory costs, ultimately the less proportion of energy was allocated to construct new tissues and caused the decreasing of CUE ratio. Meanwhile, enhanced precipitation in humid and semi-humid regions would cause the increase of photosynthesis and the decrease of fine root respiration, consequently, which led to the increase of grassland CUE (Ryan et al. 1996).

Although the MODIS GPP and NPP data had been validated by comparison with available data sources, there are many uncertainties in the CUE ratio, which was constrained by biophysical parameters in the MODIS model products (Zhang et al. 2014; Zhao et al. 2004). Moreover, this study only discussed the correlations between the grassland CUE and climate factors from 2000 to 2013, which was limited by the data availability. For more understanding of the grassland CUE variations in relation to climate change factors, a longer term condition should also be considered. But on the whole, the grassland CUE presented in this study may have fundamental significance in improving knowledge about the grassland carbon cycles under climate change.

Conclusions

This study assessed the spatiotemporal variations of the grassland CUE with the goal of understanding carbon storage and carbon cycles under climate variation at the global scale. The global grassland CUE exhibited a slightly increasing trend during the study period. And CUE varied with different grassland type. The highest and lowest average annual CUE was in the open shrublands (0.562) and savannas (0.478), respectively. The grassland CUE has considerable spatial variation associated with geographical location and featured a strong global pattern characterized by low value in warm, wet zones and high value in cold, dry environments. Furthermore, the temporal dynamics of the grassland CUE had strong correlation with temperature and precipitation. Increased temperature lowered the value of CUE and the increased precipitation led to a higher value of CUE. The outcomes of this study challenge the conventional assumption that the CUE is consistent despite of grassland type, geographical location, temperature and precipitation.

Author contributions

YY, ZQW and CCG conceived and designed the study; JLL, IO and JGQ conducted

the study. YY and YZZ analyzed data. YY and ZQW wrote the manuscript; other authors provided editorial advice. All authors have approved the final article.

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