## RESEARCH



# What factors influence thriving in adolescent and young adult cancer patients? A focus on psychological health, biological markers, and quality of life

Yi Zhou<sup>1</sup>, Yinglong Duan<sup>1</sup>, Jian Zhou<sup>2</sup>, Qinqin Cheng<sup>3</sup>, Ning Qin<sup>4</sup>, Xing Zhou<sup>4</sup>, Yuxuan Li<sup>4</sup>, Juan Luo<sup>4</sup>, Huiyi Zhang<sup>4</sup>, Jiayi Zhu<sup>4</sup>, Jianfei Xie<sup>1\*</sup> and Andy S. K. Cheng<sup>5</sup>

## Abstract

**Purpose** This study explores the role of psychological health, biological markers, and quality of life (QoL) in influencing thriving - defined as resilience and enhanced well-being - among adolescent and young adult (AYA) cancer patients.

**Methods** A total of 148 AYA cancer patients were assessed for psychological health indicators (anxiety, depression, character strengths), physiological markers (cortisol awakening response [CAR], melatonin), and QoL. Thriving levels were evaluated using ordinary least squares regression and quantile regression to identify predictors across different thriving percentiles.

**Results** Psychological health was the strongest predictor of thriving. Depression negatively impacted thriving at lower levels, while inquisitiveness consistently enhanced it. CAR and melatonin played roles at higher and median thriving levels, respectively, and QoL was most influential at lower levels. These factors collectively explained 23.0% of the variance in thriving scores.

**Conclusions** This study highlights depression, inquisitiveness, CAR, and QoL as key factors influencing thriving in AYA cancer patients. Depression affects thriving at lower levels, inquisitiveness enhances thriving consistently, CAR is significant at higher levels, and QoL is crucial at lower levels. These findings underscore the need for tailored interventions to support thriving across varying levels of adaptation.

Keywords Thriving, Adolescent and young adult, Psychological health, Biomarker, Quality of life

\*Correspondence:

Jianfei Xie

xiejianfei@csu.edu.cn

<sup>1</sup>Nursing Department, The Third Xiangya Hospital, Central South

University, Changsha 410013, Hunan, China

<sup>2</sup>College of Mechanical and Vehicle Engineering, Hunan University,

Changsha, Hunan, China

<sup>3</sup>Hunan Cancer Hospital, Changsha, Hunan, China

<sup>4</sup>Xiangya School of Nursing, Central South University, Changsha, Hunan, China

<sup>5</sup>School of Health Sciences, Western Sydney University, Sydney, Australia



© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article are included in the article's Creative Commons licence, unless indicate otherwise in a credit in to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by-nc-nd/4.0/.

## Introduction

Adolescents and young adults (AYAs) diagnosed with cancer, typically between the ages of 15 and 39, face multifaceted challenges that distinguish their experiences from those of pediatric or older oncology patients. Beyond the physical and emotional toll of cancer treatment, AYAs must navigate critical developmental milestones related to personal, social, and psychological growth [1]. In this context, thriving is conceptualized as a multidimensional state of well-being that transcends survival or resilience, integrating psychological growth, resilience, and an enhanced quality of life. Thriving reflects an individual's capacity to effectively adapt to adversity, transforming challenges into opportunities for personal and developmental growth [2, 3]. While longstanding theoretical models such as O'Leary and Ickovics'stressresponse theory and Carver's coping model provide a foundation for understanding thriving as a process of adaptive transformation, the tree metaphor offers a more integrative and dynamic framework that captures the complexity of thriving [21, 22]. The tree metaphor conceptualizes thriving as a system composed of three interconnected components: roots and soil (means), trunk and branches (process), and leaves and flowers (outcomes). The roots represent the foundational resources and environmental stability that provide the support necessary for growth, such as social, economic, and physical environments. The trunk and branches symbolize the biological and psychological processes that sustain development, including emotional regulation, stress response, and resilience mechanisms. Finally, the leaves and flowers reflect the flourishing outcomes of thriving, such as enhanced psychological well-being, improved quality of life, and overall life satisfaction [4]. This metaphor highlights thriving as a dynamic and personalized journey, shaped by the interplay of individual, environmental, and systemic factors (Fig. 1), underscoring not merely as a static endpoint but as an evolving process influenced by adaptive capacities and external conditions.

Psychological health is defined as a multidimensional construct that reflects emotional and cognitive wellbeing. In this study, it is operationalized through three key dimensions: anxiety, depression, and character strengths. These dimensions capture the core aspects of mental health that influence thriving outcomes. Previous studies consistently link thriving with reduced anxiety, fewer depressive symptoms, and strengthened character strengths [5–7]. For example, a 15-year follow-up of the Oregon Adolescent Depression Project demonstrated that adolescents identified as thriving had significantly lower incidences of anxiety disorders compared to their peers [8]. However, while these associations are well-documented in general youth populations, their specific relevance to AYAs with cancer remains underexplored. Cancer introduces unique stressors that amplify the need for targeted mental health support [9, 10]. In addition, character strengths, such as caring, inquisitiveness, and self-control, have been shown to promote resilience and thriving but may also exhibit a "dual nature," presenting challenges in adverse conditions. For example, the Norwegian COMPLETE study revealed that caring was unexpectedly associated with increased anxiety and depressive symptoms in certain contexts [11, 12]. For AYA cancer patients, engaging in behaviors aligned with personal values - rooted in strengths such as inquisitiveness and self-control - may foster resilience and enhance thriving [13, 14]. This study hypothesizes that elevated anxiety and depression negatively influence thriving, while specific character strengths positively contribute to thriving.

In the context of thriving, biological markers are measurable physiological indicators that reflect the body's stress responses and capacity for adaptation. This study focuses on two key markers: the cortisol awakening response (CAR) and melatonin levels. CAR measures the body's immediate stress response upon waking and reflects hypothalamic-pituitary-adrenal (HPA) axis activity. It has been widely validated as a robust, non-invasive marker of physiological adaptation to stress. Elevated morning salivary cortisol levels, a hallmark of dysregulated CAR, have been associated with mental health declines under stressful conditions [15]. Melatonin, a hormone secreted by the pineal gland, regulates sleep and emotional stability, supporting physical recovery and resilience [16, 17]. Its relevance lies in its direct connection to circadian rhythm stability, which is frequently disrupted in cancer patients due to treatment-related stressors. While other stress markers, such as heart rate variability or other endocrine indicators, could provide insights into physiological stress responses, CAR and melatonin were prioritized due to their complementary roles in capturing different aspects of stress regulation. Disruptions in these physiological systems can compromise the body's ability to maintain emotional resilience and overall well-being, emphasizing their potential role in thriving. This study hypothesizes that higher CAR and lower melatonin levels are negatively associated with thriving.

Quality of life (QoL) is defined as an integrative measure of overall well-being, encompassing physical, emotional, and social dimensions. For AYAs, QoL often suffers due to the long-term impacts of cancer treatment on life transitions, physical health, and emotional stability [18–20]. Thriving, in this context, requires not only physical recovery but also the ability to adapt to life disruptions while pursuing personal and developmental goals. This study hypothesizes that higher QoL is positively associated with thriving.



Fig. 1 Tree metaphor of thriving. The tree metaphor conceptualizes thriving as a dynamic and interconnected process. "Roots and soil" (Means) represent foundational resources like quality of life. "Trunk and branches" (Process) reflect biological and psychological mechanisms, such as cortisol awakening response, melatonin, depression, anxiety and character strengths. "Leaves and flowers" (Outcome) symbolize flourishing results, including enhanced well-being and life satisfaction. This framework highlights how thriving is shaped by the interplay of foundational resources, adaptive processes, and individual outcomes [4]. Reproduced from Fabian et al. (2023), published under a Creative Commons CC BY license in Journal of Happiness Studies (DOI: https://doi.org/10.1007/s10902-023-00682-y)

Building on existing literature and theoretical frameworks, this study aims to answer the following research questions:

- 1. What are the associations between psychological health indicators (anxiety, depression, and character strengths) and thriving in AYA cancer patients?
- 2. How do biological markers (cortisol awakening response and melatonin) contribute to the understanding of thriving in this population?
- 3. What role does quality of life play in mediating the relationship between psychological health and thriving?

## Methods

## Ethics, participants, and procedures

This study was conducted in accordance with the ethical standards of the Declaration of Helsinki and was approved by the Institutional Review Board of the Third Xiangya Hospital, Central South University (Approval No. 2020-S063). Written informed consent was obtained from all participants prior to their inclusion in the study. For participants under 18 years of age, informed consent was obtained from both the participants and their legal guardians. Participation was voluntary, and participants were informed of their right to withdraw from the study at any time without consequence.

This cross-sectional study was conducted with adolescents and young adults, aged 15 to 39, who received their first cancer diagnosis. Participants were recruited from two tertiary care hospitals in Hunan Province, China, chosen for their similar departmental layouts and uniform treatment and care principles, minimizing variability during data collection. To estimate the sample size, the authors aimed for a power of 80%, a significance level of 0.05, and a moderate effect size. This calculation targeted a sample size of approximately 150. Data collection occurred from June to November 2022. Initially, 162 individuals met the inclusion criteria, including confirmed cancer diagnosis, informed consent, and voluntary participation. However, during the data collection process, 14 participants were excluded due to incomplete data (e.g., missed appointments or incomplete questionnaires). This resulted in a final analysis sample of 148 participants, which was used for all statistical analyses.

## Measurement

This section outlines measurement protocols for psychological health (anxiety, depression, and character strengths), biological markers (CAR, melatonin), and quality of life assessment.

## Questionnaires

Thriving The Brief Inventory of Thriving (BIT), developed by Su et al. in 2014 [21], is a scale comprising 10 items designed to measure aspects of thriving including life satisfaction, positive emotions, support, belongingness, meaning, involvement, self-worth, self-efficacy, achievement, and optimism. Respondents rate each item on a scale from 1 (strongly disagree) to 5 (strongly agree). The total score was calculated by averaging the scores of its 10 items, yielding a final score ranging from 1 to 5, with higher total scores indicating a stronger sense of wellbeing. Primarily used in the youth demographic, the BIT has demonstrated robust psychometric properties with an internal consistency coefficient above 0.90 [22]. It not only aligns well with various other measures of psychological thriving but also distinctly separates from measures of pathological thriving. Encompassing both subjective and objective facets of health, physical functioning, and health behaviors, the BIT effectively predicts various health outcomes.

**Anxiety and depression** The Hospital Anxiety and Depression Scale (HADS), developed in 1983 by Zigmond et al. [23], is a 14-item instrument designed to assess psychological health, with its items evenly divided between 7 for anxiety and 7 for depression. Each item on the scale provides four response options, culminating in a scoring range of 0 to 21 for both anxiety and depression sections, where higher scores correspond to more severe symptoms. In the context of cancer patients, the scale has demonstrated reliability with Cronbach's alpha coefficients of 0.76 for anxiety and 0.78 for depression, affirming its effectiveness as a tool for evaluating psychological health among hospitalized patients [24].

**Character strengths** The Three-Dimensional Inventory of Character Strengths (TICS), a creation of Duan et al. in 2017 [11], is a 15-item assessment tool structured into three distinct sub-dimensions: caring, inquisitiveness, and self-control. These sub-dimensions, each comprising 5 items, are integral to the character strengths explored in this study. Respondents rate items on a scale from 1 (very unlike me) to 5 (very like me), with the average score of the five items representing the score for each sub-dimension [11]. In the current sample of adolescent and young adult cancer patients, the TICS showed good internal consistency, with Cronbach's  $\alpha$  values above 0.74 across all sub-dimensions.

**Quality of life** This study utilized the Six-Dimensional Health Short Form (SF-6D) to assess health-related quality of life, a tool derived by Brazier and colleagues [25] in 1998 from the Short Form 36 Health Survey Question-

naire. The SF-6D captures quality of life across six dimensions: physical functioning, role limitation, social functioning, pain, mental health, and vitality. Each dimension is stratified into two to six levels, with the subject's health status represented by a unique six-digit combination (e.g., "1-1-1-1-1" for perfect health and "6-2-5-6-5-5" for the poorest health). While a utility point system for the SF-6D is not yet established in mainland China, this study employed dimensional scoring for interscale comparison purposes [26]. The scale's dimensional scoring assigns 1 point for the lowest level in each dimension, incrementally increasing by 1 point for each level of improvement. The sum of all dimensional scores constitutes the total score, which is then normalized into a standard score ranging from 0 to 1 to account for the extreme differences [27].

**Demographic and diagnostic data** The demographic information gathered included age, gender, place of residence, educational attainment, marital status, and living arrangement. Diagnostic details followed, with cancer types being selected based on their incidence rates among adolescents and young adults, reflecting the most impactful cancers on this demographic according to recent epidemiological data [28, 29]. Included were breast, hematologic (such as leukemias and Hodgkin lymphoma), head and neck (such as thyroid and tongue cancers), gynecological (like cervical cancer), and less common types like colorectal cancer. Time since diagnosis was also categorized as  $\leq 6$  months and > 6 months.

## Collection of salivary samples

The sampling, collection, and transportation of saliva samples were largely conducted in accordance with the recommendations outlined in the expert consensus guidelines for CAR established by the International Society of Psychoneuroendocrinology [30]. Salivary samples were collected using the Salivette<sup>®</sup> collection system supplied by Sarstedt, Germany [31], equipped with synthetic swabs specifically designed for cortisol detection. Upon awakening in the morning, participants stimulated saliva secretion by chewing on the swab for approximately 60 s. After stimulation, the swab was returned to the Salivette® tube, which was immediately sealed with a cap. Participants were instructed to abstain from eating, drinking, or engaging in oral hygiene prior to the sample collection to prevent contamination. The second saliva sample was collected within 30 to 45 min after the first to measure the CAR. Concurrently, samples for melatonin measurement were also collected to assess nocturnal secretion levels. To minimize degradation, samples were promptly placed on dry ice in insulated boxes carried by the research team members until they could be processed. Upon arrival at the laboratory, all saliva samples were centrifuged at 1500 × g for 15 min at 4 °C. This process removed mucins and cell debris, producing a clarified supernatant which was then aliquoted and stored at -80  $^\circ\mathrm{C}$  until analysis.

#### Measurement of salivary cortisol and melatonin

Salivary cortisol and melatonin concentrations were measured using competitive enzyme-linked immunosorbent assay (ELISA) kits from IBL International, Germany (Cortisol: RE52611; Melatonin: RE54041). The assays were conducted according to the manufacturer's instructions, with optical density (OD) measured at 450-630 nm. Cortisol concentrations were quantified in ng/mL, while melatonin levels were measured in pg/mL. A standard curve was generated for each assay using a logistic regression model: cortisol concentrations were determined via a five-parameter logistic regression (5-PL) curve, while melatonin concentrations followed a four-parameter logistic regression (4-PL) model. Final hormone concentrations were calculated based on OD readings (Y-values) and converted to concentration values (X-values) using the respective regression equations. If a sample exceeded the upper detection limit, it was diluted and reanalyzed accordingly.

To ensure accuracy, all samples were assayed in duplicate, with intra-assay and inter-assay variability maintained below 10%. After initial storage at -80°C, saliva samples were later transferred to -20°C for short-term storage prior to assay. All procedures were conducted under standardized laboratory conditions to minimize variability and ensure reproducibility.

## Analysis

Statistical analyses were conducted using the R software package (version 3.6.1). Quantile regression analysis, executed through the 'quantreg' package, was used to examine associations between thriving scores and a range of psychological variables, biological markers, and quality of life factor. This approach allowed for exploring the distribution of thriving scores across various quantiles -25%, 50% (median), and 75% - highlighting trends at different levels of thriving. Graphs were produced using the `ggplot2` package to help visualize the relationships among study variables. To complement this, ordinary least squares (OLS) regression models were conducted via the 'Im' function. Missing data in cortisol and melatonin measures were addressed using multiple imputation, facilitated by the 'mice' package. Each imputed dataset was individually analyzed, and the estimates were pooled. The significance level for all statistical tests was set at  $\alpha = 0.05$ .

## Results

In this study, the final analysis sample consisted of 148 participants, reduced from an initial cohort of 162 due to exclusions for incomplete data. The cohort of AYA cancer

**Table 1** Demographic, clinical characteristics, psychological health indicators, biological markers, and quality of life of the final analysis sample (N=148)

′ariable Mean±S		
Age, years	$32.96 \pm 6.07$	
Gender		
Female	102 (62.96)	
Male	60 (37.04)	
Place of residence		
Town	118 (72.84)	
Rural	44 (27.16)	
Educational Attainment		
Junior high school and below	55 (33.95)	
High school	d 44 (27.16)	
College/University and above	rsity and above 63 (38.89)	
Marital status		
No spouse	41 (25.31)	
Spouse	121 (74.69)	
Living with family		
No	34 (20.99)	
Yes	128 (79.01)	
Type of Cancer		
Breast	37 (22.84)	
Hematology	35 (21.60)	
Head and neck	40 (24.69)	
Gynecology	23 (14.20)	
Others	27 (16.67)	
Diagnosis time, months		
≤6	116 (71.6)	
>6	46 (28.4)	
Thriving	$3.41 \pm 0.66$	
Anxiety	$8.56 \pm 2.46$	
Depression	$8.52 \pm 2.68$	
CS-C	$19.02 \pm 2.80$	
CS-I	$14.77 \pm 3.84$	
CS-SC	15.07±2.71	
CAR	$-0.28 \pm 0.70$	
<b>elatonin</b> 31.27±16.46		
QoL	0.39±0.21	

Note. The final analysis sample includes 148 participants after excluding 14 individuals with incomplete data

**Abbreviation.** CS-C: Caring of character strength. CS-I: Inquisitiveness of character strength. CS-SC: Self-control of character strength. CAR: Cortisol awakening response. QoL: Quality of life

patients had a mean age of 32.96 years, with females comprising 62.96% of the participants. Most participants resided in urban locales (72.84%), and 38.89% had a college-level education or higher. The majority of the participants (74.69%) were married, and most (79.01%) were living with family. A significant proportion of participants (71.6%) within six months of their cancer diagnosis. The most common cancer types included breast cancer (22.84%), hematological malignancies (21.60%), and head and neck cancers (24.69%). The average thriving score was 3.41 with a standard deviation of 0.66. The scores

health indicators, biological markers, and quality of life in thriving				
	Quantile of thriving			
	25%	50%	75%	
Variable	Coefficient (p)	Coefficient (p)	Coefficient (p)	
Anxiety	0.020 (0.457)	0.014 (0.586)	0.044 (0.100)	
Depression	0.090 (<0.001)	0.077 (0.002)	0.027 (0.257)	
CS-C	0.008 (0.688)	0.001 (0.947)	0.009 (0.652)	
CS-I	0.066 (<0.001)	0.058 (<0.001)	0.040 (0.006)	
CS-SC	0.005 (0.824)	0.002 (0.927)	0.027 (0.140)	
CAR	0.129 (0.169)	0.027 (0.733)	0.141 (0.020)	
Melatonin	0.001 (0.720)	0008 (0.020)	0.004 (0.214)	
OoL	0.809 (0.015)	-0.52 (0.057)	0.070 (0.783)	

Note. This table presents the results from a quantile regression analysis of psychological health indicators (anxiety, depression, CS-C, CS-I, CS-SC), biological markers (CAR and melatonin), and quality of life with respect to the 25th, 50th, and 75th quantiles of thriving among adolescent and young adult cancer patients. Coefficients are shown, with significant associations (p < 0.05) **in bold** 

**Abbreviation**. CS-C: Caring of character strength. CS-I: Inquisitiveness of character strength. CS-SC: Self-control of character strength. CAR: Cortisol awakening response. QoL: Quality of life

for anxiety and depression were relatively aligned, being 8.56 (SD = 2.46) and 8.52 (SD = 2.68) respectively. Within the dimensions of character strengths, 'caring' emerged as the most prominent trait (Mean = 19.02, SD = 2.80), succeeded by 'self-control' (Mean = 15.07, SD = 2.71) and 'inquisitiveness' (Mean = 14.77, SD = 3.84). The mean CAR in saliva was determined to be -0.28 nmol/L, while the mean salivary melatonin level stood at 31.27 pg/mL. The standard score for quality of life was calculated to be 0.39 (SD = 0.21) (Table 1).

Anxiety did not show significance at any BIT level. Depression was significant at both the 25% and 50% levels of BIT. Inquisitiveness demonstrated significant correlations with BIT across all quantiles. Biomarkers (CAR and melatonin) and quality of life exhibited significant associations across various BIT levels (Table 2). CAR was only significant at the 75% BIT level, showing no significant correlation at lower and moderate levels. Melatonin was significantly associated with the median BIT level, but not at other levels. Quality of life showed significant correlations at the 25% BIT level, but these correlations diminished at higher levels (Fig. 2).

The overall fit of the model showed that the selected variables could explain 26.8% of the variance in BIT scores, with an adjusted *R*-squared value of 23.0% (Table 3). The overall significance of the model (*F*-statistic = 7.013) was highly significant, with a *p*-value well below 0.001, indicating that the chosen variables had a significant impact on BIT scores as a whole. Among the psychological health indicators, anxiety did not reach statistical significance in positively affecting BIT scores (coefficient = 0.041, p = 0.069), suggesting a potential trend that did not meet the conventional threshold for



**Fig. 2** Coefficients of biological markers, psychological health indicators, and quality of life across various quantiles of thriving levels. Quantile regression analysis demonstrates the coefficients of biological markers (CAR, melatonin), psychological indicators [anxiety, depression, character strengths (self-control, inquisitiveness, caring)], and quality of life across thriving quantiles (25th, 50th, and 75th percentiles). The results reveal the varying impact of these factors on thriving at different levels. *Abbreviation*: CAR: Cortisol awakening response

Table 3 OLS regression analysis of psychological health
indicators, biological markers, and quality of life impacting bit
scores in adolescent and young adult cancer patients

	Coefficient	t-value	<i>p</i> -value
Const.	3.514	6.756	< 0.001
Anxiety	0.041	1.833	0.069
Depression	-0.051	-2.420	0.017
CS-C	-0.014	-0.820	0.413
CS-I	0.053	3.967	< 0.001
CS-SC	-0.007	-0.415	0.678
CAR	0.167	2.404	0.017
Melatonin	-0.004	-1.328	0.186
QoL	-0.664	-2.803	0.006

Note. The model adjusts for demographic and diagnostic variables including age, gender, place of residence, educational attainment, marital status, living with family, type of cancer, and time since diagnosis

Abbreviation. OLS: Ordinary least squares. BIT: Brief Inventory of Thriving. Const: constant. CS-C: Caring of character strength. CS-I: Inquisitiveness of character strength. CS-SC: Self-control of character strength. CAR: Cortisol awakening response. QoL: Quality of life

significance. Depression had a significant negative impact on BIT scores (coefficient = -0.051, p=0.017). Inquisitiveness had a significant positive impact on BIT scores (coefficient = 0.053, p < 0.001), while self-control and caring did not significantly affect BIT scores (coefficient = -0.007, p=0.678; coefficient = -0.014, p=0.413). Specifically, the level of CAR had a significant positive impact on BIT scores (coefficient = 0.167, p=0.017), whereas the average melatonin level did not show a significant effect (coefficient = -0.004, p=0.186). Additionally, the standard score for quality of life also showed a significant negative impact on BIT scores (coefficient = -0.664, p=0.006).

## Discussion

Among young cancer patients, thriving was significantly correlated with depression but not anxiety, highlighting their distinct effects on well-being. Depression, with its cumulative impact on energy, motivation, and life engagement, severely impairs thriving and tends to escalate over time, exacerbating distress more profoundly than anxiety, which often remains situational or transient in nature [32-35]. Depression frequently inhibits essential behaviors for thriving, such as active engagement and goal pursuit, as evidenced by studies linking behavioral inhibition caused by depression to hindered thriving in chronically ill adolescents [36]. Given these nuanced differences, interventions aimed at improving thriving among young cancer patients should prioritize managing depression, as it appears to have a more direct and sustained association with well-being. Future research should explore the mechanisms through which depression undermines thriving, focusing on how its cumulative effects on motivation and behavioral engagement may interact with resilience and coping strategies.

In contrast, the non-significant role of anxiety as a predictor of thriving in this study suggests that its effects may be more situational and short-lived. Anxiety often fluctuates with immediate stressors and, in some cases, enhances resilience by improving vigilance and problemsolving under acute stress [32, 33]. However, for cancer patients, chronic stress may diminish its relevance as survival and recovery goals take precedence. Adaptive coping strategies may further buffer anxiety's effects, reducing its direct influence on thriving outcomes.Future studies should examine the contexts and mechanisms through which anxiety interacts with thriving, including its potential to support acute coping and its diminished role under chronic stress.

This study identified a significant correlation between inquisitiveness and thriving at all quantile levels among adolescent and young adult cancer patients, highlighting its central role in promoting happiness and flourishing. In this developmental stage, the challenges of cancer may elevate the importance of strengths like inquisitiveness, which fosters growth and resilience by managing uncertainty. Kachel et al. demonstrated that growth-oriented character strengths, such as hope and zest, are strongly associated with thriving and engagement under stress [37]. Similarly, evidence from interventions enhancing character strengths has shown improved thriving and reduced negative emotions in other populations [38, 39]. These findings support the potential of characterstrength-based interventions to cultivate inquisitiveness, thereby promoting holistic thriving and recovery in young cancer patients.

In this study, CAR showed a significant relationship with thriving only at higher levels (75th percentile), with thriving increasing as CAR levels rose. This finding contrasts with initial hypothesis that higher CAR would reflect stress dysregulation and negatively associate with thriving. While elevated CAR has been linked to maladaptive stress responses in healthy populations [15], the results suggest that in cancer patients, chronic stress exposure may drive HPA axis recalibration, transforming CAR into a marker of adaptive resilience. This positive association may reflect an adaptive transformation as described by O'Leary and Ickovics' stress-response theory, where physiological systems recalibrate to support long-term resilience. Within the tree metaphor, CAR functions as part of the "trunk" (process), facilitating emotional regulation and goal-directed behaviors essential for thriving under chronic stress. Additionally, the allostatic load model suggests that sensitive CAR regulation may indicate effective stress adaptation in prolonged adversity. Supporting this, studies in breast cancer survivors have linked CAR to positive psychosocial factors, such as spiritual beliefs, suggesting that CAR may act as a protective mechanism under prolonged stress [40]. The non-linear relationship, where CAR correlates with thriving only at higher levels, suggests that its adaptive effects may depend on sufficient psychological or social resources, aligning with dose-response models of stress regulation [41]. Contextual factors such as cumulative stress exposure, baseline CAR variability, and psychosocial elements might further explain the discrepancy in CAR's role across populations. However, given the cross-sectional design of this study, the directionality of these associations remains unclear. Longitudinal research is needed to clarify the dual role of CAR as both a stress biomarker and a resilience indicator.

In this study, melatonin showed a significant relationship with thriving only at the median level (50th percentile), with no significant associations observed at lower (25th percentile) or higher (75th percentile) thriving levels. This finding contrasts with initial hypothesis that lower melatonin levels, reflecting circadian disruption, would negatively correlate with thriving. Instead, the observed association suggests that melatonin plays a stabilizing role, particularly under moderate stress and recovery conditions, where circadian rhythms and homeostatic balance are most effectively maintained. Within the tree metaphor, melatonin aligns with the "trunk" (process), representing biological mechanisms that sustain physiological stability. At the median thriving level, where stress exposure and coping mechanisms are likely balanced, melatonin's regulatory effects on sleep and emotional stability may provide essential support for maintaining homeostasis. However, under conditions of extreme stress (low thriving) or high resilience (high thriving), melatonin's role may diminish in relevance as other processes, such as HPA axis regulation (CAR) or psychological resources, take precedence. This interpretation aligns with research showing that melatonin decreases significantly under chronic stress but remains effective in acute or moderate stress scenarios [42]. Its role as a circadian regulator may be most impactful in supporting recovery during transitional phases, such as the median thriving level observed in this study. Additionally, variability in factors such as treatment-induced sleep disruption or baseline circadian rhythms could modulate melatonin's influence, potentially explaining its non-significance in regression analyses and at other thriving levels.

The significant correlation between QoL and lower thriving levels (25th percentile) in cancer patients underscores its foundational role in fostering well-being during early adaptation to illness and treatment. Within the framework of the tree metaphor, QoL aligns with the "roots and soil" (Means), providing essential resources and stability necessary for growth. At lower thriving levels, patients face heightened vulnerability in physical and emotional domains, and QoL serves as a critical determinant of their ability to withstand and adapt to the challenges posed by cancer [43–45]. This explains its strong association with thriving at these levels, as a stable QoL supports patients in meeting basic needs, alleviating distress, and fostering initial coping mechanisms. As patients progress to higher thriving levels, the role of QoL evolves. With the development of adaptive processes, such as emotional regulation and resilience, QoL shifts from being a primary driver to an outcome - analogous to the leaves and flowers (Outcomes) in the tree metaphor. This transition reflects the dynamic nature of thriving, where factors like psychological flexibility, social integration, and goal-directed behaviors become more prominent in sustaining growth and adaptation [46-48]. At higher thriving levels, QoL is maintained and supported by these well-developed processes. The finding that QoL is significant only at lower thriving levels emphasizes its central role in addressing the immediate needs of vulnerable patients, highlighting the importance of tailored interventions at this stage. Improving QoL through targeted strategies, such as symptom management, emotional support, and social integration, can strengthen the "roots" and provide the stability necessary for patients to transition to higher levels of thriving.

The study's limitations include a small sample size, a focus on time since diagnosis, and the exclusion of other biological factors relevant to thriving. The cross-sectional design prevents causal inference between thriving and factors such as depression, inquisitiveness, CAR, and quality of life. Future research should use larger, more diverse samples, adopt longitudinal designs to capture changes over time, and include additional physiological and psychological markers to better understand causal relationships.

## Conclusion

This study identifies depression, inquisitiveness, the CAR, and quality of life as key factors influencing thriving among AYA cancer patients. For instance, comprehensive psychological interventions targeting depression - such as cognitive-behavioral therapy or emotion-focused therapy - could be integrated into routine oncology care to mitigate its impact on thriving. Similarly, fostering inquisitiveness through structured curiosity-based exercises or goal-setting interventions may promote resilience and adaptive coping, particularly in higher thriving patients. At lower thriving levels, interventions that enhance quality of life, such as physical symptom management, emotional support, and social integration programs, are essential to build the foundational resources needed for growth.

#### Abbreviations

- AYA Adolescent and young adult
- BIT Brief Inventory of Thriving
- CAR Cortisol awakening response
- CS-C Caring of character strength
- CS-I Inquisitiveness of character strength
- CS-SC Self-control of character strength
- ELISA Enzyme-linked immunosorbent assay
- HADS Hospital Anxiety and Depression Scale
- HPA Hypothalamic-pituitary-adrenal
- OLS Ordinary least squares
- QoL Quality of life
- SF-6D Six-Dimensional Health Short Form
- TICS Three-Dimensional Inventory of Character Strengths

#### Acknowledgements

We extend our sincere appreciation to the adolescent and young adult cancer patients who participated in this study. Additionally, we acknowledge Fabian et al. (2023) for their work on the tree metaphor of thriving, which we have reproduced in Figure 1 under the Creative Commons CC BY license. This figure was originally published in Journal of Happiness Studies (https://doi.org/10.1007/s10902-023-00682-y), with Springer Nature as the original publisher.

#### Author contributions

YZ contributed to formal analysis, writing-original draft, and writingreview & editing. YD contributed to writing-review & editing. JZ was responsible for formal analysis. QC and NQ contributed to methodology, with NQ also participating in formal analysis. XZ, YL, and JL conducted the investigation. HZ and JZ were responsible for data curation. JX provided conceptualization, project administration, and resources. ASKC contributed to resources, supervision, and validation.

#### Funding

This research was supported by several grants: JFX received support from the National Natural Science Foundation of China under grant number 82073409 and from the Wisdom Accumulation and Talent Cultivation Project of the Third Xiangya Hospital of Central South University, grant number BJ202205. All grants contributed to the work presented in this study.

#### Data availability

The datasets generated for this study can be requested by contacting the corresponding author.

## Declarations

#### Ethics approval and consent to participate

Adherence to the Declaration of Helsinki's guidelines was ensured in this research, with ethical clearance granted by the Institutional Review Board (IRB) of the Third Xiangya Hospital, Central South University (Approval No. 2020-S063). All study participants provided informed consent prior to their inclusion in the research. For participants under the age of 16, informed consent was obtained from their parents or legal guardians, in accordance with ethical guidelines.

#### **Consent for publication** Not applicable.

not applicable.

## **Competing interests**

The authors declare no competing interests.

Received: 29 August 2024 / Accepted: 21 March 2025 Published online: 03 April 2025

#### References

- 1. National Comprehensive Cancer Network. NCCN guidelines for patients adolescent and young adult cancer 2023 [cited 2024 08/29]. Available from: h ttps://www.nccn.org/patients/guidelines/content/PDF/aya-patient.pdf
- Cho E, Docherty SL. Beyond resilience: A concept analysis of human flourishing in adolescents and young adults with cancer. ANS Adv Nurs Sci. 2020;43(2):172–89. https://doi.org/10.1097/ans.00000000000292.
- Brown DJ, Arnold R, Fletcher D, Standage M. Human thriving. Eur Psychol. 2017;22(3):167–79. https://doi.org/10.1027/1016-9040/a000294.
- Fabian M, Alexandrova A, Nair YC. Coproducing wellbeing policy: A theory of thriving in financial hardship. J Happiness Stud. 2023;24(7):2309–30. https://d oi.org/10.1007/s10902-023-00682-y.
- Baxter R, Lövheim H, Björk S, Sköldunger A, Edvardsson D. Exploring changes to resident thriving and associated factors in Swedish nursing homes: A repeated cross-sectional study. Int J Geriatr Psychiatry. 2022;37(6). https://doi. org/10.1002/gps.5731.
- Sirois FM, Hirsch JK. Associations of psychological thriving with coping efficacy, expectations for future growth, and depressive symptoms over time in people with arthritis. J Psychosom Res. 2013;75(3):279–86. https://doi.org/1 0.1016/j.jpsychores.2013.06.004.
- Rink LC, Silva SG, Adair KC, Oyesanya TO, Humphreys JC, Sexton JB. Characterizing burnout and resilience among nurses: A latent profile analysis of emotional exhaustion, emotional thriving and emotional recovery. Nurs Open. 2023;10(11):7279–91. https://doi.org/10.1002/nop2.1980.

- Olino TM, Klein DN, Seeley JR. Profiles of psychosocial and clinical functioning in adolescence and risk for later depression and other outcomes. Psychol Med. 2020;50(12):2066–74. https://doi.org/10.1017/s0033291719002186.
- Cameron N, Ross K, Baken D, Bimler D. The psychosocial interactions of adolescent and young adult cancer survivors and the possible relationship with their development. Cancer Nurs. 2021;44(1):E23–33. https://doi.org/10.1097/ ncc.00000000000732.
- Baclig NV, Comulada WS, Ganz PA. Mental health and care utilization in survivors of adolescent and young adult cancer. JNCI Cancer Spectr. 2023;7(6). htt ps://doi.org/10.1093/jncics/pkad098.
- Duan Y, Wang L, Sun Q, et al. Prevalence and determinants of psychological distress in adolescent and young adult patients with cancer: a Multicenter Survey. Asia Pac J Oncol Nurs. 2021;8(3):314–21. https://doi.org/10.4103/234 7-5625.311005.
- Geldhof GJ, Larsen T, Urke H, Holsen I, Lewis H, Tyler CP. Indicators of positive youth development can be maladaptive: the example case of caring. J Adolesc. 2019;71:1–9. https://doi.org/10.1016/j.adolescence.2018.11.008.
- Park N, Peterson C. Moral competence and character strengths among adolescents: the development and validation of the values in action inventory of strengths for youth. J Adolesc. 2006;29(6):891–909. https://doi.org/10.1016/j.a dolescence.2006.04.011.
- Proctor CJ, Reiman AJ, Best LA. Cancer, now what? A cross-sectional study examining physical symptoms, subjective well-being, and psychological flexibility. Health Psychol Behav Med. 2023;11(1):2266220. https://doi.org/10.108 0/21642850.2023.2266220.
- Zandstra AR, Ormel J, Nederhof E, Hoekstra PJ, Hartman CA. The role of basal cortisol in predicting change in mental health problems across the transition to middle school. J Adolesc Health. 2015;56(5):489–95. https://doi.org/10.101 6/j.jadohealth.2014.12.004.
- Cirulli F, Capoccia S, Berry A, Raggi C, Vomero MA, Ortona E, et al. Increased cortisol secretion, immune activation and mood changes in breast cancer patients following surgery and adjuvant chemotherapy. Eur Psychiatry. 2015;30:1510. https://doi.org/10.1016/S0924-9338(15)31167-6.
- Chang WP, Lin CC. Relationships of salivary cortisol and melatonin rhythms to sleep quality, emotion, and fatigue levels in patients with newly diagnosed lung cancer. Eur J Oncol Nurs. 2017;29:79–84. https://doi.org/10.1016/j.ejon.2 017.05.008.
- Nolan VG, Krull KR, Gurney JG, Leisenring W, Robison LL, Ness KK. Predictors of future health-related quality of life in survivors of adolescent cancer. Pediatr Blood Cancer. 2014;61(10):1891–4. https://doi.org/10.1002/pbc.25037.
- Becktell K, Simpson P, Phelan R, Schmidt D, Anderson L, Nichols J, et al. Developmental differences in health-related quality of life in adolescent and young adult cancer survivors. Qual Life Res. 2020;29(9):2435–44. https://doi.org/10.1 007/s11136-020-02507-4.
- Schulte FSM, Hou SHJ, Bender JL, Tulk J, Wurz A, Petrella A, et al. An investigation of social status among adolescents and young adults who have been diagnosed with cancer in Canada. Cancers (Basel). 2023;15(13). https://doi.or g/10.3390/cancers15133436.
- Su R, Tay L, Diener E. The development and validation of the comprehensive inventory of thriving (CIT) and the brief inventory of thriving (BIT). Appl Psychol Health Well Being. 2014;6(3):251–79. https://doi.org/10.1111/aphw.12 027.
- 22. Duan W, Guan Y, Gan F. Brief inventory of thriving: A comprehensive measurement of wellbeing. Chin Sociol Dialogue. 2016:2397200916665230.
- Zigmond AS, Snaith RP. The hospital anxiety and depression scale. Acta Psychiatrica Scandinavica. 1983;67(6):361.
- Zheng L, Wang Y, Li H. Application of the hospital anxiety and depression scale in a general hospital (Chinese version). Shanghai Archives Psychiatry. 2003;15(5):264–6.
- Brazier J, Usherwood T, Harper R, Thomas K. Deriving a preferencebased single index from the UK SF-36 health survey. J Clin Epidemiol. 1998;51(11):1115–28. https://doi.org/10.1016/s0895-4356(98)00103-6.
- Liu X, Li S, Chen G. Comparison of utility point systems in different countries and regions on the SF-6D scale (Chinese version). Chin Health Econ. 2019;38(12). https://doi.org/10.7664/CHE20191201.
- Zhang T, Wu H, Cai Y, Xiao Y, Wu J, Li M et al. A study on the current situation and factors influencing quality of life of the general population in China based on the EQ-5D-5L and SF-6D scales (Chinese version). Chin Health Service Manage. 2020;37(8).
- Bhatia S, Pappo AS, Acquazzino M, Allen-Rhoades WA, Barnett M, Borinstein SC, et al. Adolescent and young adult (AYA) oncology, version 2.2024,

NCCN clinical practice guidelines in oncology. J Natl Compr Canc Netw. 2023;21(8):851–80. https://doi.org/10.6004/jnccn.2023.0040.

- 29. Bleyer WA, Barr RD, Ries L, Whelan J, Ferrari A. Cancer in adolescents and young adults. Springer; 2007.
- Stalder T, Kirschbaum C, Kudielka BM, Adam EK, Pruessner JC, Wüst S, et al. Assessment of the cortisol awakening response: expert consensus guidelines. Psychoneuroendocrinology. 2016;63:414–32. https://doi.org/10.1016/j.psyne uen.2015.10.010.
- SARSTEDT. Salivette<sup>®</sup> Hygienic saliva collection [cited 2024 0417]. Available from: http://www.sarstedt.us/pdf/Salivette\_Brochure.pdf
- Johnson EK, Jones JE, Seidenberg M, Hermann BP. The relative impact of anxiety, depression, and clinical seizure features on health-related quality of life in epilepsy. Epilepsia. 2004;45(5):544–50. https://doi.org/10.1111/j.0013-95 80.2004;47003.x.
- Hansson L. Quality of life in depression and anxiety. Int Rev Psychiatry. 2002;14(3):185–9. https://doi.org/10.1080/09540260220144966.
- Prisnie JC, Sajobi TT, Wang M, Patten SB, Fiest KM, Bulloch AGM, et al. Effects of depression and anxiety on quality of life in five common neurological disorders. Gen Hosp Psychiatry. 2018;52:58–63. https://doi.org/10.1016/j.gen hosppsych.2018.03.009.
- Suliman S, Mkabile SG, Fincham DS, Ahmed R, Stein DJ, Seedat S. Cumulative effect of multiple trauma on symptoms of posttraumatic stress disorder, anxiety, and depression in adolescents. Compr Psychiatry. 2009;50(2):121–7. h ttps://doi.org/10.1016/j.comppsych.2008.06.006.
- Carpentier MY, Elkin TD, Starnes SE. Behavioral Inhibition and its relation to anxiety and depression symptoms in adolescents with sickle cell disease: a preliminary study. J Pediatr Oncol Nurs. 2009;26(3):158–66. https://doi.org/10. 1177/1043454209334358.
- Kachel T, Huber A, Strecker C, Höge T, Höfer S. Reality Meets belief: A mixed methods study on character strengths and Well-Being of hospital physicians. Front Psychol. 2021;12:547773. https://doi.org/10.3389/fpsyg.2021.547773.
- Bu H, Duan W. A single-session positive cognitive intervention on first-year students' mental health: Short-term effectiveness and the mediating role of strengths knowledge. J Am Coll Health. 2019;67(6):515–22. https://doi.org/10. 1080/07448481.2018.1497639.
- Zhou Y, Duan Y, Zhou J, Qin N, Liu X, Kang Y, et al. Character Strength-Based Cognitive-Behavioral therapy focusing on adolescent and young adult cancer patients with distress: A randomized control trial of positive psychology. J Happiness Stud. 2024;25(7):84. https://doi.org/10.1007/s10902-024-00795-y.
- Hulett JM, Armer JM, Leary E, Stewart BR, McDaniel R, Smith K, et al. Religiousness, spirituality, and salivary cortisol in breast cancer survivorship: A pilot study. Cancer Nurs. 2018;41(2):166–75. https://doi.org/10.1097/ncc.0000000 00000471.
- Kondrateva K, Semiglazova T, Kasparov B, Vagaitseva M, Zernova M, Krutov A, et al. Evaluation of mental and social adaptation of patients with breast cancer. J Clin Oncol. 2019. https://doi.org/10.1200/JCO.2019.37.15\_SUPPL.E23 167.
- Muñoz-Hoyos A, Molina-Carballo A, Uberos J, Contreras-Chova F, Del Carmen Augustin-Morales M, Ruiz-Alba M, et al. Serum melatonin concentration in the child with non-organic failure to thrive: comparison with other types of stress. J Biol Regul Homeost Agents. 2009;23(1):15–22.
- Al-Kaylani HM, Loeffler BT, Mott SL, Curry M, Phadke S, van der Plas E. Characterizing early changes in quality of life in young women with breast cancer. Front Psychol. 2022;13:871194. https://doi.org/10.3389/fpsyg.2022.871194.
- Bradford N, Pitt E, Rumble S, Cashion C, Lockwood L, Alexander K, Persistent, Symptoms. Quality of life, and correlates with health Self-Efficacy in adolescent and young adult survivors of childhood cancer. J Adolesc Young Adult Oncol. 2022;11(4):410–8. https://doi.org/10.1089/jayao.2021.0104.
- Salsman JM, Garcia SF, Yanez B, Sanford SD, Snyder MA, Victorson D. Physical, emotional, and social health differences between posttreatment young adults with cancer and matched healthy controls. Cancer. 2014;120(15):2247– 54. https://doi.org/10.1002/cncr.28739.
- Bonnaud-Antignac A, Hardouin JB, Leger J, Dravet F, Sebille V. Quality of life and coping of women treated for breast cancer and their caregiver. What are the interactions? J Clin Psychol Med Settings. 2012;19(3):320–8. https://doi.or g/10.1007/s10880-012-9300-9.
- He Y, Jian H, Yan M, Zhu J, Li G, Lou VWQ, et al. Coping, mood and healthrelated quality of life: a cross-sectional study in Chinese patients with advanced lung cancer. BMJ Open. 2019;9(5):e023672. https://doi.org/10.1136 /bmjopen-2018-023672.

 Macía P, Barranco M, Gorbeña S, Iraurgi I. Expression of resilience, coping and quality of life in people with cancer. PLoS ONE. 2020;15(7):e0236572. https://d oi.org/10.1371/journal.pone.0236572.

## Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.