

國立臺灣大學公共衛生學院
健康行為與社區科學研究所



碩士論文

Institute of Health Behaviors and Community Sciences

College of Public Health

National Taiwan University

Master Thesis

探討社交焦慮發展軌跡對社會性時差之影響：

以憂鬱症狀為中介變項

Associations between trajectories of social anxiety and
social jetlag: depressive symptoms as a mediator

雲惟恩

Woon, Ve Ern

指導教授：張齡尹 博士

Advisor: Ling-Yin Chang, Ph.D

國立臺灣大學碩士學位論文
口試委員會審定書

探討社交焦慮發展軌跡對社會性時差之影響：

以憂鬱症狀為中介變項

Associations between trajectories of social anxiety
and social jetlag: depressive symptoms as a
mediator

本論文係雲惟恩君 (R10850017) 在國立臺灣大學健康
行為與社區科學研究所完成之碩士學位論文，於民國 112 年
07 月 13 日承下列考試委員審查通過及口試及格，特此證明

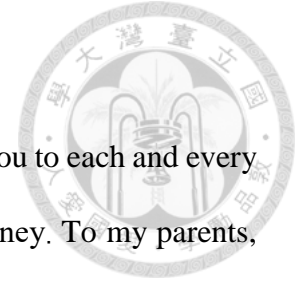
口試委員：

張新儀

吳文瑛

張齡予

Acknowledgments



First and foremost, I would like to thank God for His Grace. Thank you to each and every one of you who has been there for me throughout my Master's journey. To my parents, who provided me with the freedom and support to pursue my dreams.

To my advisor Associate Professor Ling-Yin Chang, for her dedication, mentorship, and encouragement. To my thesis defense committee, Professor Hsing-Yi Chang from National Health Research Institutes (NHRI) and Associate Professor Wen-Chi Wu from National Taiwan Normal University (NTNU), for their valuable comments. To the Child and Adolescent Behaviors in Long-term Evolution (CABLE) group for providing the precious data.

To my seminar course instructors: Professor Shu-Sen Chang and Assistant Professor Poyao Huang, for the stimulating in-class discussions and constructive feedback. To my senior and labmates: Chia-Shuan, Hsiang-Yun, Chia-Ting, and Hsien-Hsueh, for their shared knowledge and willingness to help.

To my dear Grandma, family, friends, brothers and sisters in Christ: Soon Lu, Sian Oo, Tsz Ching, Li-Wei, Chet Joe, Moomin, Hsiu-Chi, and many others, for being there.

Finally, I would also like to thank National Taiwan University for accepting me and providing a positive learning environment. My academic pursuits would not have been possible without your generous scholarship and abundant resources.

中文摘要

背景：社交焦慮對於健康的影響廣泛且深遠，是公共衛生領域重視的議題之一。社交焦慮患者睡眠問題可謂相當普及，對於他們而言，平日的社交活動及場合如同學間互動、上台報告等，將大幅增加他們的社交焦慮症狀，進而加重失眠和睡眠不足之問題。在長期睡眠不足和睡眠品質欠佳之下，睡眠債在無形之中累積，使得社交焦慮患者不得不利用休假日進行補眠，以代償身心疲勞感。週而復始的，形成社會性時差，對身心健康造成負面影響。據文獻回顧，過去並無學者分析橫跨兒童至大學時期社交焦慮之發展軌跡，且較少討論社交焦慮對於社會性時差之關係，以及憂鬱症狀在兩者之間的中介作用。

目的：本研究以成年早期之青壯年為研究對象，以長期追蹤資料進行次級資料分析，探討兒童至大學時期社交焦慮發展軌跡對於成年早期社會性時差之關係，以及憂鬱症狀在兩者之間是否扮演中介之角色。

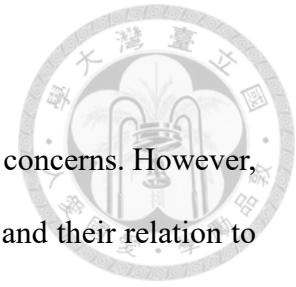
方法：本研究運用「兒童與青少年行為之長期發展研究計劃」(簡稱 CABLE 計畫)於 2001 年就讀國小一年級之第一世代，且以 2001 年至 2016 年有完整追蹤資料的學生為研究樣本。以 SAS 9.4 進行群組化軌跡模式，二元羅吉斯迴歸，以及中介分析作為主要統計方法。

結果：本研究發現五組社交焦慮發展軌跡，分別為低下降組 (49.16%)、中上升組 (21.23%)、中下降組 (16.92%)、高穩定組 (7.34%)、高上升組 (5.35%)。進一步探討社交焦慮發展軌跡與社會性時差的關係發現，「高穩定組」者比身為「低下降組」在社會性時差 (OR=1.62, $p=0.06$) 達統計上邊緣性差異。憂鬱症狀在社交焦慮軌跡 (即中上升組、中下降組和高上升組) 與社會性時差之間的關係具顯著中介效果 ($p<0.05$)。

結論：本研究發現兒童中期至成年早期的社交焦慮發展軌跡，大部分透過憂鬱症狀，進一步影響與社會性時差的關係。研究結果凸顯早期關注社交焦慮問題之重要性，並建議相關預防措施以促進成年早期之睡眠健康。最後，建議相關單位應納入憂鬱症狀作為研究或介入方案設計之考量。

關鍵字：社交焦慮、群組化軌跡、社會性時差、憂鬱症狀、中介作用

Abstract

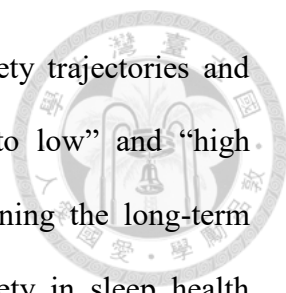


Background Social anxiety and social jetlag are major public health concerns. However, research examining the developmental trajectories of social anxiety and their relation to social jetlag is still lacking. Given the high comorbidity of depressive symptoms among socially anxious people, it is conceivable that social anxiety is associated with social jetlag indirectly through depressive symptoms. This study investigated the relationship between social anxiety trajectories and social jetlag and the mediating role of depressive symptoms on such pathways.

Methods Data were from 1,253 participants from the Child and Adolescent Behaviors in Long-term Evolution (CABLE) project across age 7 to age 22 in northern Taiwan. Group-based trajectory modeling, binary logistic regression, and mediation analyses were applied to examine distinct social anxiety trajectories from middle childhood to young adulthood and the association between these trajectory groups and social jetlag. Mediation analyses were conducted to understand the mediating role of depressive symptoms in such a relationship.

Results Participants exhibited five patterns of social anxiety trajectory, including “low stable” (49.16%), “moderate increasing” (21.23%), “moderate to low” (16.92%), “high stable” (7.34%), and “high increasing” (5.35%). Despite marginal significance, socially anxious individuals in the “high stable” group are more likely to develop social jetlag than those in the “low stable” group (OR=1.62, $p=0.06$). Depressive symptoms mediated the association between the “moderate increasing” (OR=1.06), “moderate to low” (OR=0.97), and “high increasing” (OR=1.05) social anxiety trajectories and social jetlag ($p<0.05$).

Conclusion This study found marginal significant results on higher social jetlag risk among individuals with highly stable social anxiety trajectories. Novel findings suggest



depressive symptoms mediate the association between social anxiety trajectories and social jetlag, particularly the “moderate increasing”, “moderate to low” and “high increasing” patterns. These results emphasize the need for restraining the long-term effects of social anxiety and highlighting the role of social anxiety in sleep health promotion among young adults. The presence of depressive symptoms should be considered for future research and intervention designs.

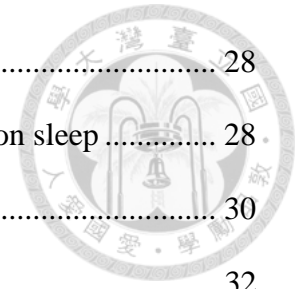
Keywords: Social anxiety; group-based trajectory; social jetlag; depressive symptoms; mediation

Table of Contents

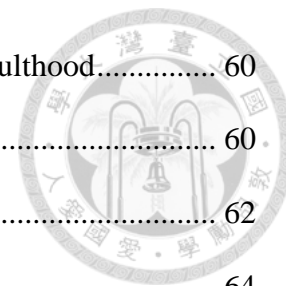


論文口試委員審定書	1
Acknowledgments	2
中文摘要	3
Abstract.....	4
Table of Contents	6
List of Figures.....	9
List of Tables.....	10
List of Appendices.....	11
Chapter 1 Introduction.....	12
1.1 Research background and motivation	12
1.2 Research importance & research objectives	16
1.3 Research questions	16
1.4 Research hypotheses.....	17
Chapter 2 Literature review	18
2.1 Social anxiety	18
2.1.1 Historical evolution of social anxiety	18
2.1.2 Definition and diagnostic criteria of social anxiety and its measurements ...	19
2.1.3 Developmental trajectories of social anxiety.....	20
2.1.4 Social anxiety and its impact on sleep.....	22
2.2 Social jetlag	25
2.2.1 Definition and development of social jetlag and its measurements	25
2.2.2 Social jetlag in young adulthood and its impact.....	26
2.3 Mediating role of depressive symptoms.....	28

2.3.1 Definition and diagnostic criteria of depression.....	28
2.3.2 Depressive symptoms in young adulthood and its impact on sleep	28
2.4 Potential covariates	30
Chapter 3 Method	32
3.1 Research Framework	32
3.2 Data source	33
3.3 Study sample	33
3.4 Measurements	36
3.4.1 Independent variable: social anxiety	37
3.4.2 Dependent variable: social jetlag.....	39
3.4.3 Mediating variable: depressive symptoms	41
3.5 Covariates	42
3.5.1 Sex	42
3.5.2 Parental education.....	42
3.5.3 Parental income	42
3.5.4 Family structure.....	43
3.5.5 Family support.....	44
3.5.6 Peer support	44
3.6 Statistical analyses	46
3.6.1 Descriptive statistical analysis.....	46
3.6.2 Inferential statistical analysis.....	46
3.7 Research procedure.....	53
3.8 Ethical considerations.....	53
Chapter 4 Results.....	55
4.1 Sample characteristics	56



4.2 Social anxiety trajectories from middle childhood to young adulthood.....	60
4.2.1 Model selection	60
4.2.2 Patterns of social anxiety trajectories	62
4.2.3 Characteristics of social anxiety trajectories	64
4.3 Bivariate association between study variables	67
4.3.1 Association between continuous variables and social jetlag	67
4.3.2 Association between categorical variables and social jetlag	68
4.4 Association between social anxiety trajectories and social jetlag	71
4.5 Depressive symptoms as a mediator.....	72
Chapter 5 Discussion.....	77
5.1 Social anxiety trajectories from middle childhood to young adulthood.....	77
5.2 Associations between social anxiety trajectories and social jetlag.....	80
5.3 Mediating effect of depressive symptoms on the relationship between social anxiety trajectories and social jetlag.....	83
5.4 Study strengths and limitations	85
Chapter 6 Conclusion and Implications	87
6.1 Conclusion.....	87
6.1.1 Characteristics of social anxiety, social jetlag, and other variables	87
6.1.2 Social anxiety trajectories from middle childhood to young adulthood.....	87
6.1.3 Associations between social anxiety trajectories and social jetlag.....	87
6.1.4 Mediating role of depressive symptoms between social anxiety trajectories and social jetlag	88
6.2 Implications	88
References	90
Appendices	112



List of Figures



Figure 1 Research framework.....	32
Figure 2 Overview of group-based trajectory modeling.....	48
Figure 3 Study flowchart	55
Figure 4 Distribution of social jetlag	59
Figure 5 Social anxiety trajectories from age 7 to age 20	63
Figure 6 Path diagrams for total effect and indirect effect of social anxiety trajectories on social jetlag through depressive symptoms	76

List of Tables



Table 1 CABLE study timeline	35
Table 2 Data waves used for each variable.....	36
Table 3 Operational definition of study variables.....	45
Table 4 Sample characteristics of categorical variables	57
Table 5 Sample characteristics of continuous variables	58
Table 6 Model fit results	61
Table 7 Model adequacy results	62
Table 8 Sociodemographic characteristics of social anxiety trajectories	65
Table 9 Bivariate association between continuous covariates with social jetlag.....	67
Table 10 Bivariate association between categorical covariates with social jetlag.....	69
Table 11 Bivariate association between social anxiety trajectories and social jetlag....	70
Table 12 Regression coefficients for mediation analyses.....	74
Table 13 Indirect effects of social anxiety trajectories on social jetlag.....	75

List of Appendices



Appendix 1: Regulations for the usage of CABLE project data	112
Appendix 2: Institutional Review Board Approval Letter	113
Table A1 Social anxiety.....	114
Table A2 Social jetlag.....	115
Table A3 Depressive symptoms	115
Table A4 Covariates	116
Table A5 Comparison between complete cases and original sample characteristics..	118

Chapter 1 Introduction



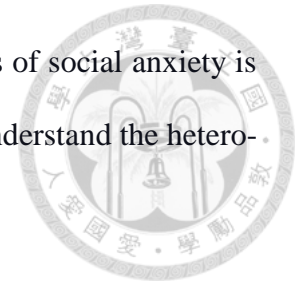
1.1 Research background and motivation

Humans are inherently social beings. Being social is inevitable; whether we are family members, friends, students, or workers, each role requires us to interact with others. Social interactions start ever since we are young and are deeply embedded in our everyday life. We connect with others through socializing, and these interactions affect how we build relationships with people. Social connections fulfill the third level of Maslow's Hierarchy of Needs (i.e., love and belongingness) and impact our health and well-being (Maslow, 1943). Socializing is normal to us, but sadly, it is not the case for some people. Individuals with social anxiety may be distressed even in these day-to-day social events.

Social anxiety is an excessive and persistent fear of being judged by others in social situations (M. B. Stein & Stein, 2008). It is a critical mental health issue that can cause harm to our physical, mental, and social health, disrupting our lives in many ways, including our daily activities, interpersonal relationships, social life, and even our quality of life. Social anxiety is a common disorder normally occurring during late childhood or adolescence, with a mean age of onset at 13. However, studies suggest that some individuals might develop this disorder at an earlier period or maybe later. Children may develop early-onset social anxiety as young as six years of age, and surprisingly, young adults aged 18 to 24 may be at risk, too (Hirshfeld-Becker et al., 2007; Jefferies & Ungar, 2020; Wittchen et al., 1999).

While most studies asserted that social anxiety lessens as individuals aged, some argued otherwise (Campbell, 1996; Kessler et al., 2005). These inconsistencies might, on the other hand, suggest diversity and dynamic progression of social anxiety over time (Nandi

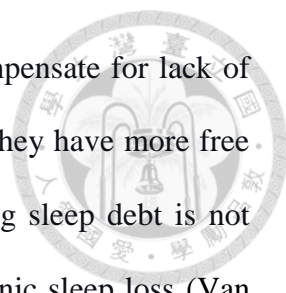
et al., 2009). However, empirical study on the developmental trends of social anxiety is scarce. Herein, the use of trajectory analyses may be beneficial to understand the heterogeneity in the development of social anxiety.



Developmental trajectory analysis is widely used to identify changes in a particular phenomenon over time (Nagin, 1999). Social anxiety trajectory analyses are conducted in prior studies, and heterogeneous patterns have been identified for children, adolescents, and young adults. Three to five distinct trajectories are found in previous works; however, most of them focused on a specific age group with a limited span of 6 to 7 years (Chang et al., 2010; de la Torre-Luque et al., 2020; Miers et al., 2013). Few analyzed the trajectories of social anxiety across childhood and adolescence, much less till early adulthood. To the best of my knowledge, only one study from the Netherlands has examined social anxiety trajectories in a cross-age group sample of children aged 9 to young adults aged 21, which remarkably spanned 12 years (Miers et al., 2013).

Moreover, the majority of research is performed in Western countries. There is a relative lack of evidence on social anxiety trajectories among the Asian or Taiwanese population. Only one domestic study analyzed similar courses among individuals aged 10 to 17 in Taiwan (Chang et al., 2010). Social anxiety trajectories of those before age 10 and after age 17 are not investigated. Clearly, the developmental nature of social anxiety from childhood to young adulthood among the Taiwanese population is understudied.

Due to repetitive negative thinking and rumination, people with social anxiety often have insomnia and poor sleep quality (Buckner et al., 2008; Horenstein et al., 2019; Staner, 2003). Subsequently, feelings of nighttime restlessness, daytime sleepiness, fatigue, and

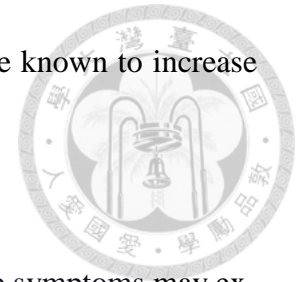


sleep debt pile up due to sleep loss (Pillai & Drake, 2015). To compensate for lack of sleep during the week, one would sleep longer on weekends when they have more free time away from school and work obligations. Indeed, accumulating sleep debt is not equivalent to being tired, and some people may even adapt to chronic sleep loss (Van Dongen et al., 2003). However, this is not always the case. In general, sleeping in on weekends remained a common approach to catching up on lost sleep, albeit the ongoing debate whether catchup sleep could counteract compromised sleep (Leger et al., 2020).

Therefore, social phobics may experience a weekday-to-weekend sleep difference, otherwise known as social jetlag. It is defined as the discrepancy between the midpoints of sleep on work and free days (Wittmann et al., 2006). Social jetlag is a universal problem that may contribute to various health and behavioral issues, including mood disorders and impaired job performance. Social jetlag occurs across age groups but is more prevalent among the younger population (Wittmann et al., 2006), particularly among adolescents and early adulthood. Nevertheless, the latter age group is rarely discussed, not to mention the relationship between social anxiety trajectories and social jetlag in young adulthood.

Besides sleep problems and potential social jetlag issues, depressive symptoms are another main concern for socially anxious individuals. Ample evidence showed the co-occurrence of social anxiety and depressive symptoms (M. B. Stein et al., 2001; Väänänen et al., 2011; Van Ameringen et al., 1991). Based on the fact that people with social anxiety fear negative evaluations by others (Hirsch et al., 2004), they are more likely to avoid direct social contact, hence, less likely to maintain or even establish social relationships (S. M. Turner et al., 1986). This inability may lead to alienation by others and, in the long term, deepen their feelings of rejection, loneliness, and social isolation (Oren-Yagoda et

al., 2022; Rapee & Spence, 2004; Teo et al., 2013), all of which are known to increase chances of depressive symptoms (M. B. Stein et al., 1990).



Theoretically, socially anxious individuals with comorbid depressive symptoms may experience poorer sleep than those without depressive symptoms, as hyperactivity of the hypothalamic-pituitary-adrenal (HPA) axis was persistently found among depressive people (Vreeburg et al., 2009). Elevated secretion of cortisol (stress hormone) from the HPA axis causes an abnormal stress response and may worsen sleep disturbance (Rodenbeck & Hajak, 2001; Spiegel et al., 1999). In addition to the sleep problems that arise from social anxiety, it is possible that depressive symptoms may aggravate the negative cycle of poor sleep aforementioned above. Therefore, people with social anxiety and comorbid depressive symptoms might opt to reduce sleep deficits by extending their sleep duration, especially during free time and on weekends, thus, more likely to develop social jetlag.

One finding also suggested the potential mediating role of depressive symptoms. A study by Buckner et al. (2008) investigated the mediating role of depressive symptoms in the effects of social anxiety and sleep-related outcomes (i.e., insomnia) and found that socially anxious individuals were more vulnerable to the risk of depressive symptoms, resulting in poorer sleep. Given the evidence available and that depressive symptoms are an established risk factor for sleep problems, it is conceivable that social anxiety is associated with social jetlag indirectly through depressive symptoms (Buysse et al., 2008; Soehner et al., 2014). However, little is known about the potential mediating role of depressive symptoms in the link between social anxiety and social jetlag. In sum, there is a

need to examine the association between social anxiety trajectories and social jetlag, with depressive symptoms as a mediator.



1.2 Research importance & research objectives

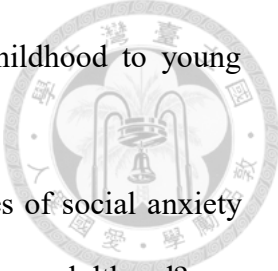
To address the gaps in the literature, including (1) the scarce evidence on the developmental trajectory of social anxiety from childhood to early adulthood among Taiwanese; (2) the possible yet unexplored relationship between social anxiety trajectories and social jetlag during young adulthood; and (3) the lack of research on the mediating role of depressive symptoms in the link between such association. Therefore, this study aims to:

1. Analyze the developmental trajectories of social anxiety across middle childhood to young adulthood;
2. Demonstrate the relationship between social anxiety from middle childhood to young adulthood and social jetlag in young adulthood;
3. Explore the mediating role of depressive symptoms on the relationship between social anxiety trajectories and social jetlag.

Results from this study will enhance our understanding of longitudinal changes in social anxiety on social jetlag and may provide valuable insights into developing effective strategies to decrease social jetlag. For instance, if depressive symptoms are an established mediator, interventions targeting highly comorbid depressive symptoms could yield promising outcomes.

1.3 Research questions

The present study's questions are:

- 
1. What are the patterns of social anxiety trajectories from childhood to young adulthood?
 2. Is there an association between the developmental trajectories of social anxiety from childhood to early adulthood and social jetlag during young adulthood?
 3. Do depressive symptoms mediate the relationship between social anxiety and social jetlag?

1.4 Research hypotheses

Based on the above research questions, this study hypothesizes:

1. Individuals with social anxiety from middle childhood to young adulthood exhibit distinctive trajectory patterns.
2. Individuals with higher trajectories of social anxiety are more likely to develop social jetlag during young adulthood.
3. Individuals with higher social anxiety trajectories are more likely to have higher depressive symptoms, leading to a higher probability of developing social jetlag.

Chapter 2 Literature review



2.1 Social anxiety

2.1.1 Historical evolution of social anxiety

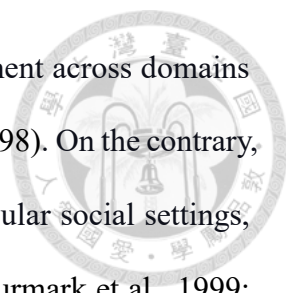
Social anxiety is initially known as social phobia in the early 1900s. Until that time, social anxiety was not officially recognized as a disease. Historical evolution of social anxiety can be traced back to 400 B.C., over 2400 years ago, when ancient Greek physician Hippocrates first described such a condition as shyness. Later in 1903, French psychiatrist Pierre Janet introduced the term social phobia (*phobie des situations sociales*) and proposed an individual classification among other phobias. In between that time, social phobia remained undiagnosed. People would experience anxiety and fear in social situations but would not be diagnosed or treated for it. It was instead considered a personal weakness or shyness, and individuals were expected to overcome their fears independently.

In 1987, the American Psychological Association (APA) officially recognized social phobia as a mental disease. It is defined as “persistent fear of one or more situations in which the person is exposed to possible scrutiny by others and fears that he or she may do something or act in a way that will be humiliating or embarrassing” (American Psychiatric Association, 1987). Diagnostic criteria of social phobia in the revised third edition of the Diagnostic Statistical Manual of Mental Disorders (DSM-III-R) can be found elsewhere (American Psychiatric Association, 1987). Decades after the introduction of social phobia, social phobia was renamed as social anxiety disorder (SAD) in the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) in 1994 (American Psychiatric Association, 1994).

2.1.2 Definition and diagnostic criteria of social anxiety and its measurements

Social anxiety, also known as social anxiety disorder (SAD) or social phobia, is characterized by excessive and persistent fear or anxiety in social situations (American Psychiatric Association, 2013). Social anxiety has been officially classified as a psychiatric condition since 1980 and is an anxiety disorder. According to the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), individuals with social anxiety may experience symptoms including (1) intense fear or anxiety of being scrutinized by others during social situations; (2) feeling anxious or scared at almost every social situation; (3) tendency to avoid social situations or endure with an intense feeling of distress; (4) persistent fear, anxiety, and avoidance for at least six months; (5) overwhelming fear, anxiety, or avoidance that affects social, work, and other aspects of life; (6) unreasonable fear of social events that posed no actual harm; and (7) symptoms not attributable to any physical or mental condition. Other than the diagnostic criteria stated in various editions of DSM, instruments for the assessment of social anxiety include Liebowitz Social Anxiety Scale (LSAS), Social Phobia Scale (SPS), Social Phobia and Anxiety Inventory (SPAI), Social Interaction Anxiety Scale (SIAS), and Social Phobia Inventory (SPIN) (Q. Wong et al., 2016).

According to the fourth edition of DSM, social anxiety can be categorized into two distinct subtypes: generalized and non-generalized social anxiety. Individuals with generalized social anxiety fear most or all social situations, whether formal or informal (Hofmann et al., 1999). Specifically, individuals must experience moderate anxiety levels in four cases: formal social interaction, informal social interaction, observation by others, and assertive communication (Holt et al., 1992).



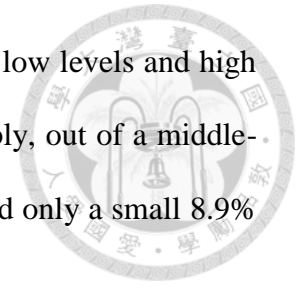
The generalized subtype is associated with substantial impairment across domains and increased risk for psychiatric comorbidity (Kessler et al., 1998). On the contrary, those with non-generalized forms fear only one or a few particular social settings, such as performance-related situations like public speaking (Furmark et al., 1999; Moutier & Stein, 1999; S. M. Turner et al., 1992). Differentiation between generalized and non-generalized social anxiety can be done based on the specific number or types of social situations feared, the difference in biological patterns, or scores of measurement scale (Norton et al., 1997; Vriends et al., 2007).

2.1.3 Developmental trajectories of social anxiety

Developmental trajectories depict the change in behavior over time. Trajectory analyses can aid a better understanding of the long-term trends in social anxiety and its influence on health. Based on an extensive literature search, studies specifically exploring the developmental trajectory of social anxiety were limited, and most were conducted in Western countries like the United States, Canada, and the Netherlands. To the best of my knowledge, only one study by Chang et al. (2010) explored social anxiety trajectories among Taiwanese adolescents.

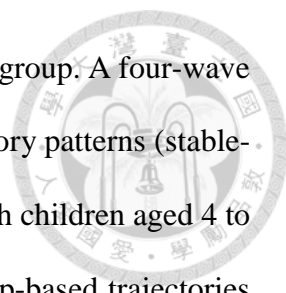
A U.S. study by Feng et al. (2008) identified four distinct trajectories of anxiety symptoms among 290 boys aged 2 to 10: low, low increasing, high declining, and high increasing. Mainly, the low group consisted of continuous low anxiety symptoms; the low-increasing and high-increasing groups showed a rapid increase from age 3 onwards. A five-wave longitudinal study by Crocetti et al. (2009) discovered two latent classes of anxiety (low and high anxiety) among two adolescent cohorts aged 10 to 15 and 16 to 20. Specifically, the low and high anxiety

classes consisted of adolescents who experienced persistently low levels and high but gradually increasing levels of anxiety, respectively. Notably, out of a middle-sized sample of 1,199 people, the high anxiety class comprised only a small 8.9% of the sample.



A Canadian secondary data analysis by Duchesne et al. (2008) distinguished four anxiety trajectories (low, moderate, high, and chronic anxiety) among 1,817 Canadian preschoolers. Compared to the relatively flat moderate or high group, the low group displayed a gradually decreasing pattern, while the chronic group appeared to fluctuate. Another study also by Duchesne et al. (2010) identified four but rather different patterns than their previous investigation using group-based trajectory modeling (low, low increasing, high declining, and high anxiety groups). The low and high declining groups were fairly stable after a steep increase and decrease, respectively, at grade one age. The low increasing group increased remarkably since grade one, while the high anxiety displayed a wavering pattern on top.

As for the social anxiety-specific study, a multilevel growth curve analysis by Van Oort et al. (2009) revealed two patterns of social anxiety (moderate increasing and high stable) using three-wave adolescent samples aged 10 to 18. Both patterns exhibited a decreasing start and subsequent increasing pattern after mid-adolescence. A U.S. six-wave study by Marmorstein et al. (2010) identified five trajectory groups among six girl-specific cohorts aged 5 to 13 (low, low increasing, moderate, moderate decreasing, and high). In particular, low increasing, moderate, moderate decreasing, and high decreasing showed sharp increases or decreases in



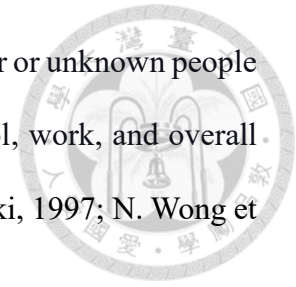
social anxiety symptoms compared to the relatively stable high group. A four-wave study by Broeren et al. (2012) found four social anxiety trajectory patterns (stable-low, stable-medium, stable-high, stable-very high) in 224 Dutch children aged 4 to 11 using parents-reported measurements. The latter three group-based trajectories demonstrated a slightly decreasing social anxiety pattern since the start. Conversely, the stable-low trajectory was relatively flat. Miers et al. (2013) identified three distinct social anxiety trajectories (low stable, more decreasing, and high changing) in a small sample of 331 Dutch people using latent class growth modeling (LCGM).

2.1.4 Social anxiety and its impact on sleep

Social anxiety is a common mental disease that affects millions of people worldwide. It is the third most common mental disorder after major depressive disorder and alcohol use disorder (Kessler et al., 2005). According to the data from the National Comorbidity Survey Replication (NCS-R), social anxiety is a critical mental health issue with a global prevalence rate of 36% and a lifetime prevalence rate ranging from 4% to 12.1% (Grant et al., 2005; Jefferies & Ungar, 2020; Kessler et al., 2005; D. J. Stein et al., 2017). Although social anxiety usually begins during adolescence, some might develop such a disorder early. Prevalence rates for childhood and adolescent social anxiety disorder were 3 to 6.8% and 0.5% to 9%, respectively (Hitchcock et al., 2009).

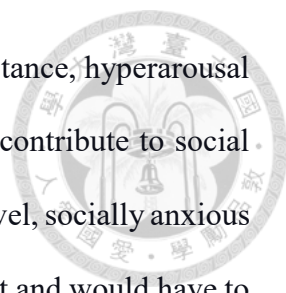
Social anxiety can impact us every day in many ways. In everyday life, persistent and excessive fear of social situations may jeopardize one's relationship with others. Symptoms of fear are particularly evident during social interaction with strangers (Kearney, 2006). Daily activities like buying groceries, going to work, or having in-

class discussions may be affected, as interacting with unfamiliar or unknown people is sometimes unavoidable. Our everyday life, including school, work, and overall quality of life, can be substantially impaired (Leary & Kowalski, 1997; N. Wong et al., 2012).



Besides wellbeing, social anxiety is well known for its debilitating effects on health. The impact of social anxiety on physical health can be significant, with research suggesting that social anxiety is associated with various adverse health outcomes. A large number of studies reported that social anxiety is associated with a high comorbidity with other mental health diseases like depression, alcohol abuse, substance use, and even suicide (Lecrubier & Weiller, 1997; Lépine & Pélissolo, 1996; Schneier et al., 1992; Van Ameringen et al., 1991). Especially, epidemiological findings demonstrated frequent co-occurrence of social anxiety and depression (Ohayon & Sagales, 2010; M. B. Stein et al., 2001). Also, elevated mortality risk among socially anxious individuals is revealed (Meier et al., 2016).


Sleep is notably affected by social anxiety. People diagnosed with social anxiety commonly exhibit sleep problems like insomnia, poor sleep quality, and frequent sleep disturbances, probably due to habitual negative thinking and recurring fears (Staner, 2003; M. B. Stein et al., 1993). These sleep disturbances may be attributable to the extreme fear of social situations that cause heightened arousal and vigilance, making it harder to relax and fall asleep (Mellman, 2006). Insomnia and sleep fragmentation may eventually occur, disrupting the sleep-wake cycle.



Based on the sleep problems triggered by social anxiety, for instance, hyperarousal and insomnia, it is plausible to assert that social anxiety may contribute to social jetlag (Bonnet & Arand, 2010). As sleep dictates one's energy level, socially anxious people with poor sleep may unknowingly accumulate sleep debt and would have to pay them off during weekends. In this case, sleeping in on the weekends would eventually lead to social jetlag. On the other hand, lack of sleep can worsen symptoms of social anxiety, creating an endless loop of social anxiety, sleeplessness, catchup sleep, and social jetlag (Babson et al., 2011). Sadly, no study has examined the association between social anxiety and social jetlag. Research on their relationship is very much needed.

2.2 Social jetlag

2.2.1 Definition and development of social jetlag and its measurements



Before clocks and artificial light were invented, human ancestors slept after sunset and woke up during sunrise. Their active and rest times were determined by their biological clock - an inborn mechanism that regulates the 24-hour biological rhythms of all living things (Kreitzman & Foster, 2011). This particular mechanism, widely known as circadian rhythm, was first discovered in plants by French chronobiologist Jean-Jacques d'Ortous de Mairan in 1727. This novel discovery then laid the foundation of modern chronobiology. Research on circadian rhythm has gained interest in recent years due to the growing understanding of its importance on health. Unfortunately, it has become increasingly evident that the misalignment of circadian rhythm is a serious public health concern among adults, especially young adults (Di et al., 2022; McMahon et al., 2018).

This misalignment between one's biological and social clocks problem is then coined as social jetlag (SJL) by chronobiologist Till Roenneberg. It is defined as 'the discrepancy between workdays and free days, between social and biological time,' where workdays and free days resemble one's social and biological time, respectively (Wittmann et al., 2006). Social jetlag is calculated based on the absolute difference in the midpoint of sleep between free days (MSF_{sc}) and workdays (MSW) (Wittmann et al., 2006). The adjusted midpoint of sleep during free days is corrected for sleep debts on work days (i.e., sleep duration on free days minus average weekly sleep duration). The equation for social jetlag is demonstrated below.

$$SJL = |MSF_{sc} - MSW|$$

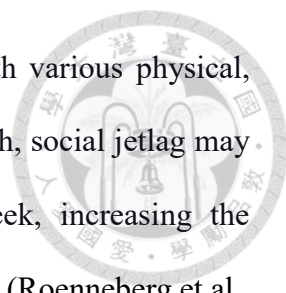
$$MSF_{sc} = MSF - (SDF - (5 \times SDW + 2 \times SDF) \div 7)$$



There is no official cut-off point to discriminate against this phenomenon. Social jetlag has been analyzed in categorical or continuous form (Mathew et al., 2020; Parsons et al., 2015; P. M. Wong et al., 2015). However, most of the studies have been categorizing social jetlag using a cutoff value of 1-hour to determine the presence of social jetlag. Some research dichotomized social jetlag, with <1-hour as the absence of social jetlag and ≥ 1 hour as the presence of social jetlag (Mota et al., 2021), while others categorized social jetlag in an ordinal matter: <1-hour as mild or no social jetlag, 1 to 2 hours as moderate social jetlag, and >2 hours as severe social jetlag (Gamboa Madeira et al., 2021; Jin et al., 2022; Koopman et al., 2017; Roenneberg et al., 2012; Rutters et al., 2014). Of course, other methods, including 2-hour threshold or using median social jetlag as a cutoff point, have been used in previous studies (Hena & Garmy, 2020; Levandovski et al., 2011; Sůdy et al., 2019).

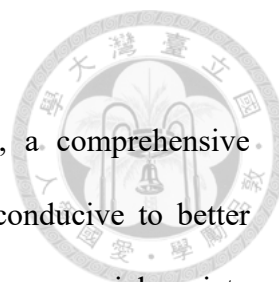
2.2.2 Social jetlag in young adulthood and its impact

Social jetlag is a highly prevalent issue that needs to be addressed. Large scale study of 65,000 people found that more than two-third of the sample had at least 1-hour of social jetlag (Roenneberg et al., 2012). Besides that, adolescents and young adults, especially those with late chronotype, may be at greater risk for social jetlag (Martínez-Lozano et al., 2020).



Social jetlag is harmful to human health. It is associated with various physical, mental health, and behavioral problems. Regarding sleep health, social jetlag may cause individuals to accumulate sleep debt during the week, increasing the likelihood of sleep deprivation, daytime sleepiness, and fatigue (Roenneberg et al., 2004). Furthermore, an irregular sleep schedule attributable to social jetlag may reduce sleep quality and, at the same time, promote circadian misalignment (Juda et al., 2013). A growing body of evidence suggests that a disrupted circadian rhythm can increase the risk of obesity, diabetes, cardiovascular diseases, and other metabolic issues

Social jetlag is associated with obesity, diabetes, cardiovascular, and other metabolic diseases (Mota et al., 2021; Parsons et al., 2015; Rutters et al., 2014; P. M. Wong et al., 2015). Moreover, Henderson et al. (2019) suggested that social jetlag is detrimental to psychological health and has been linked to depressive symptoms (Islam et al., 2020). Studies also identified the relationship between social jetlag and unhealthy behavior, including tobacco and alcohol use, excessive caffeine consumption, and poor eating habits (Bodur et al., 2021; Haynie et al., 2018; Mathew et al., 2020; Wittmann et al., 2006).



2.3 Mediating role of depressive symptoms

Given that social anxiety was highly comorbid with depression, a comprehensive literature review on the impact of depressive symptoms may be conducive to better understand the roles of depressive symptoms in the relationship between social anxiety trajectories and social jetlag.

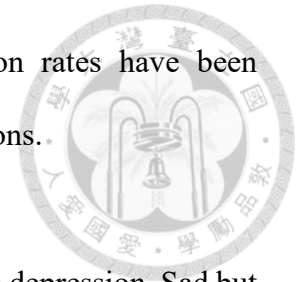
2.3.1 Definition and diagnostic criteria of depression

For depression diagnosis, the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) states that individuals must experience at least five out of nine evaluation criteria for at least two weeks for depressive symptoms and one must experience at least five of them for at least two weeks, including (1) Persistent sadness, anxiousness, and feelings of emptiness; (2) Loss of interest or pleasure in most activities; (3) Significant unintentional weight loss or gain; (4) Insomnia or hypersomnia; (5) Psychomotor agitation or retardation; (6) Prolonged fatigue or loss of energy; (7) Feelings of worthlessness or excessive guilt; (8) Diminished ability to think or concentrate; (9) Recurrent thoughts of death, suicidal ideation, or suicide attempts (American Psychiatric Association, 2013).

2.3.2 Depressive symptoms in young adulthood and its impact on sleep

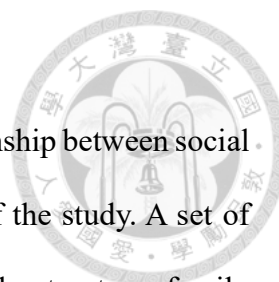
Depression is a health concern, especially for young people. Global burden of this issue has been alarming. A National Center for Health Statistics 2022 study reported a greater risk of depressive symptoms among young adults aged 18 to 29 than middle-aged and older adults (Villarroel & Terlizzi, 2020). Statistics from the National Institute of Mental Health (NIMH) in 2020 revealed a prevalence rate of

17% among adults aged 18 to 25. Significantly, depression rates have been increasing, not only in the United States, but also in other nations.



The health and well-being of tens of millions are at stake due to depression. Sad but true, depression is the leading cause of disability (Friedrich, 2017). In addition, it affects the three dimensions of health (i.e., physical, mental, and social), and sleep. Clearly, depressive people are no stranger to sleep problems like insomnia and excessive sleepiness, as sleep problem is a prominent symptom of depression besides depressed mood (Kennedy, 2008; Nutt et al., 2008).

To conclude, based on three reasons: unexamined trajectories of social anxiety from childhood to young adulthood; the unexplored relationship between social anxiety trajectories and social jetlag; and the potential mediating role of depressive symptoms in the link between social anxiety and social jetlag, this present study would like to examine whether depressive symptoms is a mediator between social anxiety trajectories and social jetlag among Taiwanese population.



2.4 Potential covariates

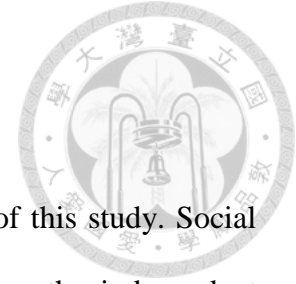
Potential covariates should be considered when examining the relationship between social anxiety trajectories and social jetlag, for it could affect outcomes of the study. A set of covariates including sex, parental education, parental income, family structure, family support, peer support, prior depressive symptoms, and prior social jetlag, were selected. Each of them was controlled during the analysis.

Previous studies suggested the influence of sex on the developmental course of social anxiety. Females are more likely to report symptoms of social anxiety than males. Moreover, individuals from disadvantaged backgrounds, including those living in rural areas, with low socioeconomic status (i.e., having parents with lower levels of education and income), are at higher risk of developing social anxiety (Kaplan et al., 2019; Kinge et al., 2021; Lyneham & Rapee, 2007; Torvik et al., 2020). Family structure is associated with poorer sleep (Nilsen et al., 2022; Troxel et al., 2014). Additionally, research suggested that individuals with low parental education were more likely to develop social jetlag. There are several factors for this tendency, including economic instability and social difficulties faced by low-income households. These individuals may be exposed to higher stress levels and mental challenges, such as exposure to conflict or violence, which could further exacerbate symptoms of social anxiety and follow irregular sleep schedules. Hence, sociodemographic factors like sex, parental education, and parental income should be considered when discussing social jetlag.

Furthermore, Levine et al. (2015) reported that parent-child emotional closeness is protective against social anxiety, whereas low family support is a risk factor. Clear evidence indicates the influences of paternal and maternal behavior on socially anxious

children (Bögels et al., 2010). Besides familial factors, poor peer relations are associated with adverse mental outcomes (Adedeji et al., 2022; de Matos et al., 2003). Evidence suggested that those with low peer acceptance were more likely to develop social anxiety and that girls with limited close friendships are particularly vulnerable (Pickering et al., 2020). Therefore, to better grasp the influence of social anxiety trajectories on social jetlag, each covariate mentioned above, as well as prior history of depressive symptoms or social jetlag, should be included in the analysis.

Chapter 3 Method



3.1 Research Framework

The conceptual framework is constructed based on the objectives of this study. Social anxiety trajectories from middle childhood to young adulthood are the independent variable, whereas social jetlag during early adulthood is the dependent variable. Depressive symptoms are the mediator variable between social anxiety trajectories and social jetlag. Potential covariates include sex, parental education, parental income, family structure, family support, peer support, prior depressive symptoms, and prior social jetlag.

Figure 1 presents the framework graphically.

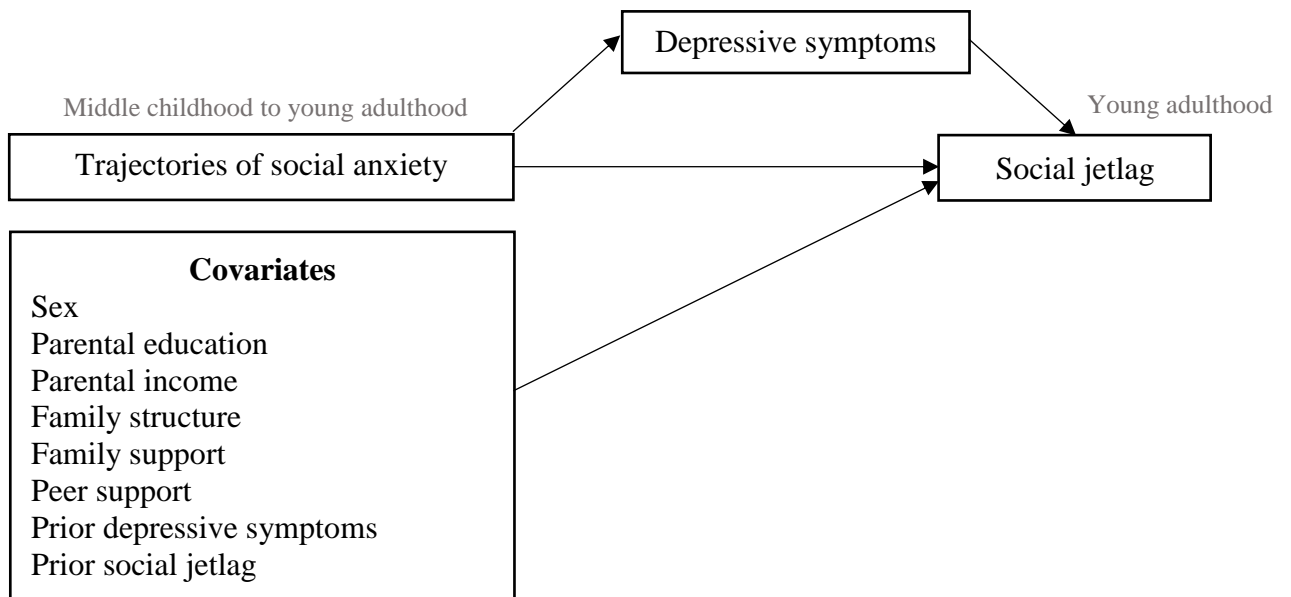


Figure 1 Research framework

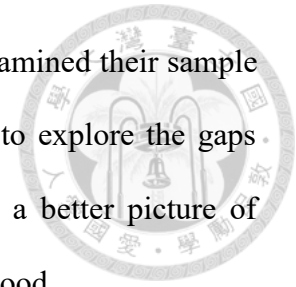
3.2 Data source

Data for the present study were obtained from the Child and Adolescent Behaviors in Long-term Evolution (CABLE) study conducted in Taiwan (L. L. Yen et al., 2002). It is a longitudinal project aimed at understanding the development of children and adolescents from a socioecological perspective (i.e., individual, family, and school context). A total of eighteen elementary schools from Taipei City and Hsinchu County were randomly selected, each representing urban and rural areas in northern Taiwan, respectively. School size was first categorized based on the number of enrolled first-grade students: small (50 to 199 students), middle (200 to 399 students), and large (more than 400 students). Then, nine schools with a combination of six small schools, two middle schools, and one large school were chosen from each area to ensure equitable number of students sampled from each school category. All first graders (cohort one) and fourth graders (cohort two) were sampled from the selected schools. Both cohorts were sampled and followed annually from 2001 to 2016, then biennially from 2017 to the present (**Table 1**). Additional information regarding sampling frame and study design can be found elsewhere (L. L. Yen et al., 2002).

3.3 Study sample

This secondary analysis included data from cohort one, followed annually from 2001 to 2016. Such a cohort was selected based on four reasons. First, cohort two has been analyzed by Chang and colleagues' (2010) study on the trajectories of social anxiety among Taiwanese adolescents, whereas cohort one is unexplored. Second, given that children may develop social anxiety as young as age 6, it is best to choose the first-grader cohort one, which contains data as early as age 7, over cohort two, which started with age 10 fourth graders (Hirshfeld-Becker et al., 2007). Third, as the study by Miers et al. (2013)

on social anxiety trajectories from childhood to young adulthood examined their sample starting from age 9, analyzing cohort one would allow this study to explore the gaps between ages 7 and 9. Last, data from cohort one could provide a better picture of Taiwanese' social anxiety trajectories from childhood to early adulthood.



Cohort one participants were in first grade to senior year of college or young adults (age 7 to 22) during this period. Sixteen waves of data were collected in total. Analysis samples were limited to four inclusion criteria: (1) participants from cohort one; (2) completed at least two waves of social anxiety surveys from wave 1 to wave 14 (age 7 to age 20); (3) completed depressive symptoms survey during wave 15 (age 21); and (4) had social jetlag data during wave 16 (age 22).

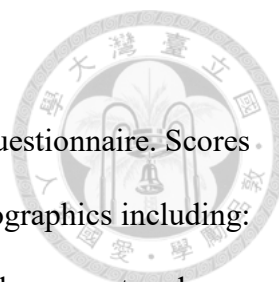
Participants were excluded if: (1) completed only one of wave 1 through wave 14 (age 7 to age 20) social anxiety surveys; (2) had missing depressive symptoms data during wave 15 (age 21); (3) had missing social jetlag data during wave 16 (age 22); (4) participants had extreme sleep duration (less than 3 hours or more than 14 hours), as they were more likely to have sleep disorders; and (5) participants with extreme sleep timing (i.e., midsleep later than noon)(Li et al., 2020; McMahon et al., 2018, 2019). Attrition rates were calculated and response rate of each wave was demonstrated. A flowchart illustrates the inclusion and exclusion of individuals in the study in the result section.



Table 1 CABLE study timeline

Grade Age	Elementary school						Middle school			High school			College or University						
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
2001	A1			B1															
2002		A2			B2														
2003			A3			B3													
2004				A4			B4												
2005					A5			B5											
2006						A6			B6										
2007							A7			B7									
2008								A8			B8								
2009									A9			B9							
2010										A10			B10						
2011											A11			B11					
2012												A12			B12				
2013													A13			B13			
2014														A14			×		
2015															A15			×	
2016																A16			B16
2017																	×		
2018																		×	
2019																			A19

Note: A for cohort one; B for cohort two

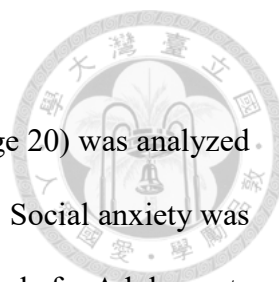


3.4 Measurements

Variables used in this study were obtained from the student version questionnaire. Scores of social anxiety, social jetlag, and depressive symptoms; basic demographics including: sex, age, parental education, parental income, family structure; family support and peer support were collected. Data waves used for each variable as shown in **Table 2**. Operational definitions and scoring of variables are described in **Table 3**. Cronbach's alpha tests were conducted to assess internal consistency and a reliability coefficient of 0.70 or above was considered acceptable (Cronbach, 1951).

Table 2 Data waves used for each variable

Year	2001 - 2006						2007 - 2012						2013 - 2016			
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Wave no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Social anxiety	•	•	•	•	•	•	•	•	•	•	•	•	•	•		
Social jetlag																•
Prior social jetlag							•	•	•	•	•	•	•	•		
Depressive symptoms															•	
Prior depressive symptoms	•	•	•	•	•	•	•	•	•	•	•	•	•	•		
Sex	•															
Parental education				•			•			•	•		•	•		
Parental income	•	•	•	•	•											
Family structure	•	•	•	•	•	•	•	•	•	•	•	•	•	•		
Family support	•	•	•	•	•	•	•	•	•	•	•	•	•	•		
Peer support							•	•	•	•	•	•	•	•		



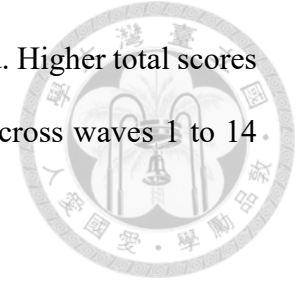
3.4.1 Independent variable: social anxiety

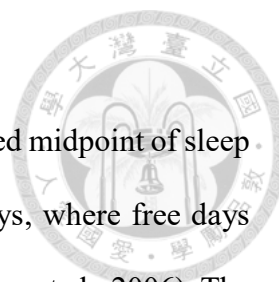
Participants' social anxiety from wave 1 to 14 (from age 7 to age 20) was analyzed to demonstrate the developmental trajectories of social anxiety. Social anxiety was measured using seven items adapted from the Social Anxiety Scale for Adolescents (SAS-A) at each assessment wave (La Greca & Lopez, 1998). Participants were asked about their experiences in the past two weeks on whether they “fear of meeting new friends,” “fear of being ridiculed by others,” “fear of talking to strangers,” “fear of being laughed at,” “fear of being judged,” “fear of being disliked,” and “fear of performing or answering questions in front of others” (see **Table A1**).

The original scale contains eighteen items assessing symptoms of social anxiety among adolescents. CABLE study used a shorter version of seven items, covering only two out of three domains: fear of negative evaluation (FNE) (four items) and social avoidance specific to new situations or unfamiliar peers (SAD-N) (three items). The social avoidance and distress in general (SAD-G) domain was excluded from the study.

Items from the FNE domain include (1) fear of being ridiculed by others; (2) fear of being laughed at by others; (3) fear of being judged by others; and (4) fear of others who will dislike me. Items from the SAD-N include (1) fear of meeting new people; (2) fear of talking to unfamiliar people; and (3) fear of doing something new in front of others (**Table A1**). All items were assessed using a 3-point scale from 1 (never), 2 (once or twice), to 3 (multiple times). Scores from each year were summed to yield a total social anxiety score ranging from 7 to 21. Total score was

set to missing, if more than three missing responses were found. Higher total scores indicate greater severity of social anxiety. Cronbach's alpha across waves 1 to 14 was between 0.74 to 0.90.





3.4.2 Dependent variable: social jetlag

Social jetlag (SJL) is the absolute difference between the adjusted midpoint of sleep during free days and the unadjusted midpoint during work days, where free days and work days each resemble weekends and weekdays (Wittmann et al., 2006). The adjusted midpoint of sleep during free days is corrected for sleep debts on work days (i.e., sleep duration on free days minus average weekly sleep duration). Social jetlag is calculated using two formulas shown below:

$$SJL = | MSF_{sc} - MSW |$$

$$MSF_{sc} = MSF - (SDF - (5 \times SDW + 2 \times SDF) \div 7)$$

In the formula, SDF and SDW represent sleep duration on free days and work days, respectively; whereas $(5 \times SDW + 2 \times SDF) \div 7$ refers to the average sleep duration per week. Two items were obtained, including bedtimes and wakeup times for weekends and weekdays measured in 2016 (see **Table A2**). Baseline values of social jetlag from wave 7 to 14 (age 13 to age 20) were also measured and controlled.

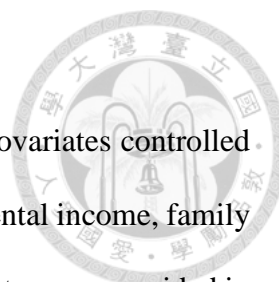
Social jetlag has been analyzed in categorical and continuous form due to the lack of consensus on the clear-cut boundaries of social jetlag (Beauvalet et al., 2017). Both continuous and categorical measures of social jetlag have their advantages and limitations. As for this study, social jetlag was modeled as a categorical variable using a cutoff point of 1-hour, as previously done by (Koopman et al., 2017; Mota et al., 2021; Roenneberg et al., 2012; Rutters et al., 2014). Specifically, less than 1-hour of social jetlag was coded as 0; while more than 1-hour of social jetlag was coded as 1. Justifications for the categorization of social jetlag were as follows: (1) Evidence has shown that social jetlag with a cutoff point of 1-hour correlates with

an increased risk of several health issues, including obesity, diabetes, and cardiovascular disease (Henderson et al., 2019; Rusu et al., 2019; Stoner et al., 2018); (2) better interpretability than continuous as categorical social jetlag provides a clear and simple way of grouping individuals based on their degrees of social jetlag (E. L. Turner et al., 2010); (3) better understand the association of social anxiety trajectories on different degrees of social jetlag (E. L. Turner et al., 2010).

3.4.3 Mediating variable: depressive symptoms

Depressive symptoms were defined as the average score of participants' depressive symptoms during wave 15 (age 21). Baseline values of depressive symptoms between waves 1 to 14 (from age 7 to 20) were also collected. Participants were asked to provide self-reported depressive symptoms during the past two weeks at each wave using six items from the Center for Epidemiological Studies Depression Scale for Children (CES-DC). These items include (1) loss of appetite; (2) feeling sad; (3) crying for no reason; (4) getting upset over nothing; (5) feeling scared; and (6) lack of motivation to do anything (Faulstich et al., 1986).

Depressive symptoms in the CABLE study were initially assessed using seven items in **Table A3**. However, an item (i.e., difficulty sleeping) was excluded from the present study to avoid overlapping issues with social jetlag. Responses were measured on a 3-point scale from 1 = never, 2 = once or twice, to 3 = multiple times. All items were summed and averaged to create a depressive symptoms score. A higher score indicates higher levels of depressive symptoms. Cronbach's alphas across waves 1 to 15 (from age 7 to age 21) were 0.63 to 0.83.



3.5 Covariates

This section provides the definition and measurements of potential covariates controlled during the study analysis, including sex, age, parental education, parental income, family structure, family support, and peer support. Questions of each covariate were provided in **Table A4** and **Table A5**.

3.5.1 Sex

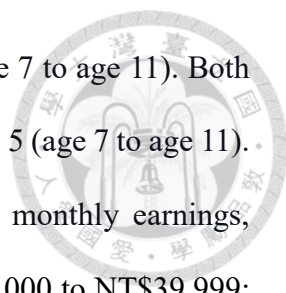
Sex was defined as participants' biological sex provided at wave 1 (age 7). Male was coded as 1, whereas female was coded as 2.

3.5.2 Parental education

Parental education was defined as the highest level of education attained by the participant's father and mother between wave 4 and wave 14 (age 10 to age 20). Both paternal and maternal education levels were measured during wave 4 (age 10), wave 7 (age 13), wave 10 to 11 (age 16 to age 17), and wave 13 to 14 (age 19 to age 20). Student participants were asked to provide their parents' education level, ranging from 1 = elementary school; 2 = junior high school; 3 = high school; 4 = vocational high school; 5 = junior college; 6 = college or university; and 7 = graduate school. All data were recoded into 1 = junior high school or below; 2 = high school; and 3 = university or above. To note, parental education was controlled separately: paternal education and maternal education.

3.5.3 Parental income

Parental income was defined as parents' self-reported average monthly income, which includes salaries, agricultural income, business revenue, investment income,

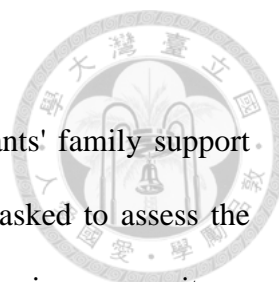


allowances, bonuses, and dividends, between waves 1 to 5 (age 7 to age 11). Both paternal and maternal income were measured during waves 1 to 5 (age 7 to age 11). Parents were asked to provide information on their average monthly earnings, ranging from 1 = less than or equal to NT\$19,999; 2 = NT\$20,000 to NT\$39,999; 3 = NT\$40,000 to NT\$59,999; 4 = NT\$60,000 to NT\$79,999; 5 = NT\$80,000 to NT\$99,999; 6 = NT\$100,000 to NT\$119,999; 7 = NT\$120,000 to NT\$139,999; 8 = NT\$140,000 to NT\$159,999; to 9 = NT\$160,000 and above. All data were recoded into 1 = less than or equal to NT\$39,999; 2 = NT\$40,000 to NT\$99,999; and 3 = NT\$100,000 and above. Parental income was controlled individually: paternal income and maternal income.

3.5.4 Family structure

Family structure was defined as the participants' parental marital status and living situation between waves 1 to 14 (age 7 to age 20). Original scoring for parental marital status was 1 = married; 2 = divorced; and 3 = unmarried. The living situation was investigated by asking participants whether one of their parents was deceased, only came home on weekends, and whether their parents lived together.

Single-parent household is defined as participants with the following conditions: (1) separated parents; (2) divorced parents; (3) widowed parents; or (4) unmarried parents. A dual-parents household is defined as participants with two married living parents living together. For those considered as dual-parents households, participants must have married parents that are: (1) both alive; (2) living together; (3) either father or mother came home for the weekends. Family structure were recoded into 0 = single-parent household; and 1 = dual-parents household.



3.5.5 Family support

Family support was defined as the average score of participants' family support between waves 1 to 14 (age 7 to age 20). Participants were asked to assess the perceived support received from their father and mother, using seven items including (1) parental encouragement; (2) parental praise; (3) parental comfort; (4) parental care; (5) active listening from parents; (6) parental initiative; and (7) parental advice. All items were measured on a 4-point scale from 1 = never; 2 = once or twice; 3 = multiple times, to 4 = every time. Each score was totaled and averaged to reflect a mean score of family support. A higher score indicates better parental support.

3.5.6 Peer support

Peer support was defined as participants' average peer support score during waves 7 to 14 (age 13 to age 20). Participants were asked to evaluate the perceived peer support using twelve items, including (1) friends who listen to me when I am angry; (2) friends who care about me; (3) friends who comfort me when I am feeling sad; (4) friends who spend time together; (5) friends who share belongings; (6) friends who helped to solve problems; (7) friends who give advice when I need to make decisions; (8) friends who give advice from time to time; (9) friends who explain when I do not understand; (10) friends who talk about my strengths; (11) friends who compliment when I did well; and (12) friends who ask for my advice. Items were measured on a 5-point scale from 1 = never; 2 = rarely; 3 = occasionally; 4 = frequently; to 5 = always. Each score was totaled and averaged to reflect a mean score of peer support. A higher score indicates better support from peers.

Table 3 Operational definition of study variables

Variable (Year)	Description	Coding
Independent variable		
Social anxiety (2001-2014)	Participants' response to the 7-item scale regarding their social anxiety symptoms over a 2-week time interval.	Each item = 1-3 scale Score range = 7-21
Dependent variable		
Social jetlag (2016)	Participants reported their bedtimes and wakeup times on free days and work days, then calculated based on the absolute difference between midpoint of sleep on free days adjusted for sleep debt (MSF _{sc}) and midpoint of sleep during work days (MSW)	0 = < 1-hour 1 = ≥ 1-hour
Mediating variable		
Depressive symptoms (2015)	Participants' response to the 6-item scale on whether they experienced depressive symptoms over a 2-week time interval.	Each item = 1-3 scale Score range = 6-18
Covariates		
Sex (2001)	Participants' biological sex	1 = male 2 = female
Parental education (2004, 2007, 2010-2011, 2013-2014)	Participants' responses on their father's and mother's highest education attainment.	1 = junior high or below 2 = high school 3 = university or above.
Parental income (2001-2005)	Participants' father and mother self-disclose their respective average monthly income	1 = ≤NT\$39,999 2 = NT\$40,000-NT\$99,999 3 = ≥NT\$100,000
Family structure (2001-2014)	Participants' responses on their parent's marital status and living situation	0 = single-parent household 1 = dual-parents household
Family support (2001-2014)	Participants' responses on perceived family support from their father and mother	Each item = 1-4 scale Score range = 7-28
Peer support (2007-2014)	Participants' response on their perceived peer support	Each item = 1-5 scale Score range = 12-60
Prior depressive symptoms (2001-2014)	Participants' response to the 6-item scale on whether they experienced prior depressive symptoms over a 2-week time interval.	Each item = 1-3 scale Score range = 6-18
Prior social jetlag (2007-2014)	Participants' prior experience of social jetlag	0 = <1-hour 1 = ≥1-hour



3.6 Statistical analyses

3.6.1 Descriptive statistical analysis

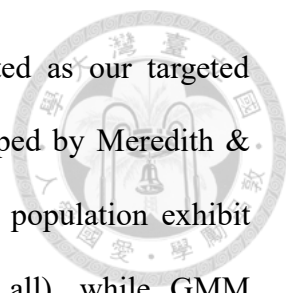
Descriptive statistics were performed to demonstrate the sample characteristics. Mean, standard deviation, and range were presented for the continuous variables, whereas proportion of values in each category was presented for the categorical variables.

3.6.2 Inferential statistical analysis

For specific aim one, the present study applied group-based trajectory modeling to explore the developmental trajectories of social anxiety from middle childhood to young adulthood. For specific aim two, multiple linear regression was conducted to examine the association between different patterns of social anxiety trajectories and social jetlag during young adulthood. For specific aim three, mediation analysis was applied to study the mediating role of depressive symptoms in the link between social anxiety trajectories and social jetlag. Details are described in the following sections. All procedures were performed using Statistical Analysis System (SAS) statistical software, version 9.4, SAS Institute Inc., Cary, NC, USA.

Group-based trajectory modeling

The present study used group-based trajectory modeling (GBTM) to identify trajectory patterns of social anxiety from middle childhood to young adulthood using wave 1 to 14 (age 7 to age 20) social anxiety data (Nagin, 1999). GBTM is one of the trajectory modeling approaches used in longitudinal data analysis and has been extensively implemented in long-term health and behavioral outcome research, just as techniques like latent growth curve modeling (LGCM) and growth



mixture modeling (GMM). Nevertheless, GBTM was selected as our targeted approach for the following reasons. Such that LGCM developed by Meredith & Tisak (1990) generally assumes individuals within the same population exhibit homogeneous patterns of change (i.e., one trajectory fits all), while GMM introduced by Muthén & Shedden (1999) assumes that sub-populations with heterogeneous trajectories, at the same time allows an intra-class variation. Unlike LGCM and GMM, GBTM proposed by Nagin & Land (1993) presumes a mixture of trajectory groups (i.e., differences between subgroups) within a population, but not differences within subgroups. In short, GBTM is a much better alternative regarding outcome comparability, interpretability, and practicality (Nagin & Odgers, 2010; Ram & Grimm, 2009). The GBTM analysis was performed using the SAS PROC TRAJ written by Jones et al. (2001) and conducted in three steps: (1) model specification; (2) model estimation; and (3) model selection and interpretation (Nguefack et al., 2020).

Model specification and estimation

According to Nagin (1999), the GBTM procedure consists of three key components, including (1) optimal number and shapes of trajectory groups; (2) proportion of the sample assigned to each group, as well as (3) individual probability of belonging to the assigned group.

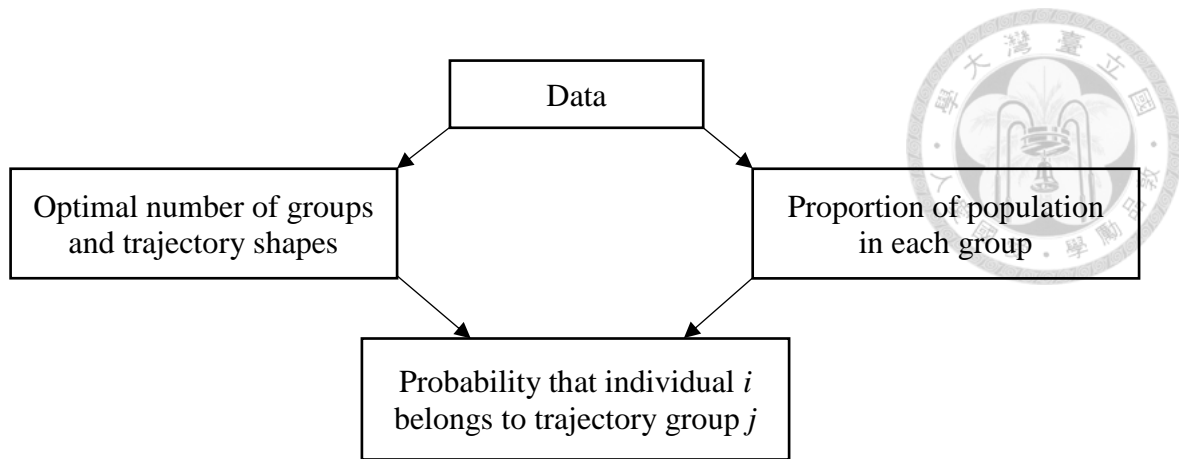


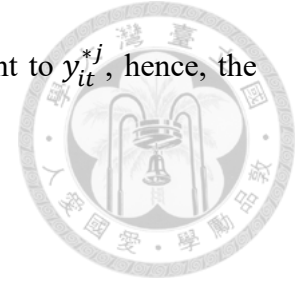
Figure 2 Overview of group-based trajectory modeling

Firstly, the appropriate choice of model should be decided as GBTM can be carried out in three ways, depending on the data type obtained: (1) zero-inflated Poisson (ZIP) regression model; (2) binary logit model; and (3) censored normalized (CNORM) model. Specifically, the Poisson model is designed to analyze count data (i.e., number of occurrences of an event). As the name implies, the binary logit model is suitable for binary data (i.e., outcomes that consist only of two distinct values). Last, the censored normalized (CNORM) model estimates psychometric data with clusters either at the minimum or maximum end or both. Given that social anxiety is adapted from a questionnaire and measured in continuous form; thus, the censored normal model is preferred. The formula of the selected model is shown below.

$$y_{it}^{*j} = \beta_0^j + \beta_1^j Age_{it} + \beta_2^j Age_{it}^2 + \dots + \beta_n^j Age_{it}^n + \varepsilon_{it}$$

y_{it}^{*j} is the individual i 's measurement of social anxiety at time t within group j . Censored counterpart y_{it} contains maximum value S_{max} and minimum value S_{min} . y_{it} is equal to S_{max} if y_{it}^{*j} is smaller than S_{min} ; conversely, when y_{it} is equal to

S_{min} if y_{it}^{*j} is larger than S_{max} ; whereas when y_{it} is equivalent to y_{it}^{*j} , hence, the value of y_{it}^{*j} will be between S_{min} and S_{max} (Nagin, 1999).



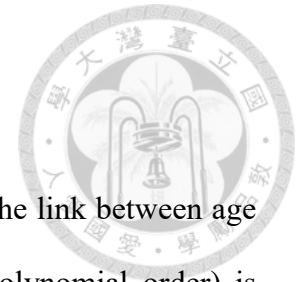
$$\text{Vector } Y_i = \{Y_{i1}, Y_{i2}, \dots, Y_{iT}\}$$

Vector Y_i denotes the longitudinal measurements of individual i 's social anxiety during time period T. While $\beta_0^j, \beta_1^j, \dots,$ and β_n^j are coefficients that determine the shape of each trajectory; $Age_{it}, Age_{it}^2, \dots,$ and Age_{it}^n each represents individual i 's age at time t , the square of individual i 's age at time t , et cetera, respectively. ε_{it} refers to the disturbance of displaying a normal distribution.

As for group estimation, two methods are to be considered, either through maximum likelihood or Bayesian estimation. For our study, the maximum likelihood estimation (MLE) method is applied after considering that MLE is suitable for longitudinal data with missing at random (MAR) values and that it yields unbiased parameter estimates. Notably, group-based trajectories are the product of maximum likelihood estimation (Nagin, 1999). Therefore, the maximum likelihood estimation is applied for our model estimation, and its formula is as demonstrated.

$$P(Y_i) = \sum_j^J \pi_j P^j(Y_i)$$

$P^j(Y_i)$ indicates the probability of Y_i assigned membership in group j ; where Y_i refers to the longitudinal measurements of individual i 's targeted behavior; π_j represents the posterior probability of membership in group j . As a whole, $P(Y_i)$ indicates the unconditional probability of Y_i ; $\sum_j^J \pi_j P^j(Y_i)$ stands for the summation of the individual i 's measurements and the probability of being randomly assigned to groups (from group j to J).

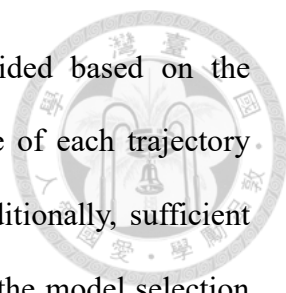


Model selection and interpretation

Furthermore, a polynomial relationship is assumed to model the link between age or time and behavior. A quartic relationship (i.e., highest polynomial order) is presumed, as the PROC TRAJ procedure disallows a polynomial order greater than quartic. First, the one-group model with the highest polynomial order was tested before gradually increasing the group number. Process is carried on until the optimal number of groups (i.e., the number of groups that best fit the data) is achieved based on a combination of three model fit criteria: (1) lowest value (i.e., nearest to zero) of Bayesian information criteria (BIC); (2) log Bayes factor of the Bayesian information criterion ($2\Delta\text{BIC}$) greater than 10; and (3) lowest value (i.e., nearest to zero) of Akaike information criteria (AIC) (Akaike, 1974; Schwarz, 1978).

Other than that, specific selection criteria were introduced for assessing model adequacy. Five criteria are ought to be met, including: (1) an average posterior probability (AvePP) greater than the recommended value of 0.7; (2) odds of correct classification (OCC) exceeding the minimum threshold of 5; (3) trajectory size of each group larger than 5% of the sample; (4) close match between estimated group membership probabilities and proportion assigned to each group; and (5) narrow confidence interval of estimated group membership probabilities (Nagin, 1999; Nagin & Odgers, 2010).

After deciding the optimal number of groups, model refinement was carried out by adjusting the polynomial order for each trajectory group. Different combinations of



polynomial orders were tested, and the best one was decided based on the parameters with the highest significant term. Next, the shape of each trajectory group should be concluded and reflect the original data. Additionally, sufficient knowledge from previous studies is equally important during the model selection process.

Bivariate analyses

Bivariate analyses were conducted accordingly. The Chi-squared test was used to measure the relationship between two categorical variables for not normally distributed data. Mann-Whitney U and Kruskal Wallis H test compared differences between two or more than three-grouped categorical and continuous variables, respectively. A p -value less than 0.05 is considered statistically significant.

Multiple logistic regression

The crude effect of social anxiety trajectories from middle childhood to young adulthood on social jetlag in young adulthood was examined. Multiple logistic regression was then conducted while controlling for potential covariates. Specifically, model 1 adjusted for sociodemographic characteristics, including sex, parental education, parental income, and family structure. total effects of social anxiety trajectories on social jetlag after adjustment for covariates, prior depressive symptoms and prior social jetlag (c_1, c_2, c_3, c_4 path).

Mediation analysis

Depressive symptoms were added to test for hypothesized mediation. Total effects including both direct and indirect effects were analyzed. Mediation analysis with

complete case analysis was performed through bootstrap, to test whether depressive symptoms would mediate the association between social anxiety trajectories and social jetlag. Procedure was done using the PROCESS macro for SAS developed by Preacher & Hayes (2004) which can be found at www.processmacro.org.

The association between trajectories of social anxiety and depressive symptoms (a_1 , a_2 , a_3 , a_4 path); between depressive symptoms and social jetlag (b path) after controlling for sex, parental education, parental income, family structure, family support, peer support, prior depressive symptoms, and prior social jetlag; as well as the direct effects of social anxiety trajectories on social jetlag after controlling for depressive symptoms, covariates, and prior depressive symptoms and prior social jetlag (c' path) were computed.

Compared to classic mediating tests like Sobel's test (1982) or the Baron & Kenny (1986) approach, the bootstrapping method is much preferred for smaller samples, and it does not impose the assumption of normality (Hayes, 2013; Preacher & Hayes, 2004, 2008). In addition, the indirect effect can be estimated without needing a statistically significant total effect (Hayes, 2013). Therefore, testing of the mediation hypothesis would proceed even under the presence of a nonsignificant total effect. The mediating role of depressive symptoms would be established when the 95% bias-corrected bootstrap confidence interval (CI) does not contain 1.

3.7 Research procedure

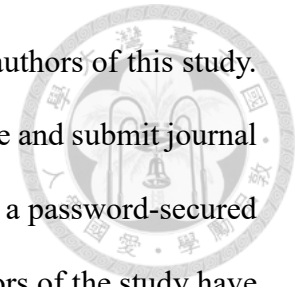
This study used secondary data analysis from 10th November 2022 to 30th June 2023. The procedures were as follows: (1) Data collection from 10th November 2022 to 15th December 2022; (2) Data analysis and interpretation were performed afterward till 31st March 2023; and (3) Thesis writing and correction would end around 30th June 2023, plus or minus one month.

3.8 Ethical considerations

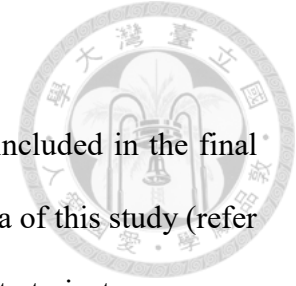
The present study is reviewed and approved by the National Taiwan University Behavioral and Social Sciences Research Ethics Committee (case number: 202210HM004). The source of this secondary quantitative analysis, CABLE study, is a long-term, ongoing project funded and managed by the National Health Research Institute (NHRI) of Taiwan. Student participants, parents, and guardians were well-informed about the purpose of the CABLE study. Their participation was entirely voluntary. At the baseline survey, written informed consent was obtained from every student's parent or legal guardian. Data from this secondary data analysis study are non-identifiable to protect the respondents' confidentiality and privacy. Therefore, the potential risk of harm to individual subjects was less than minimal.

Access to data requires formal application to the CABLE research group via email (cable@nhri.org.tw). Mandatory documents to be submitted include application form, research proposal, and Institutional Review Board (IRB) approval letter. After the review and approval process, questionnaires and coding books were provided to select required variables. Importantly, all data acquired are solely for the present study and may not be used for other purposes. During the data collection and analysis stage, relevant files and

folders were password-protected. Access to data is restricted to the authors of this study. Following the completion of this study, authors are obliged to prepare and submit journal manuscript for publication. Data and research records were stored in a password-secured folder, for five years upon completion of the research. To note, authors of the study have no conflicts of interest to declare.



Chapter 4 Results



A total of 1,253 participants (48.52% male; 51.48% female) were included in the final analysis, after excluding those who did not meet the inclusion criteria of this study (refer to **Figure 3**). Sample characteristics, model selection of social anxiety trajectory groups, bivariate association between study variables, association between social anxiety trajectories and social jetlag, and mediating effect of depressive symptoms on the relationship between social anxiety and social jetlag are demonstrated in this chapter.

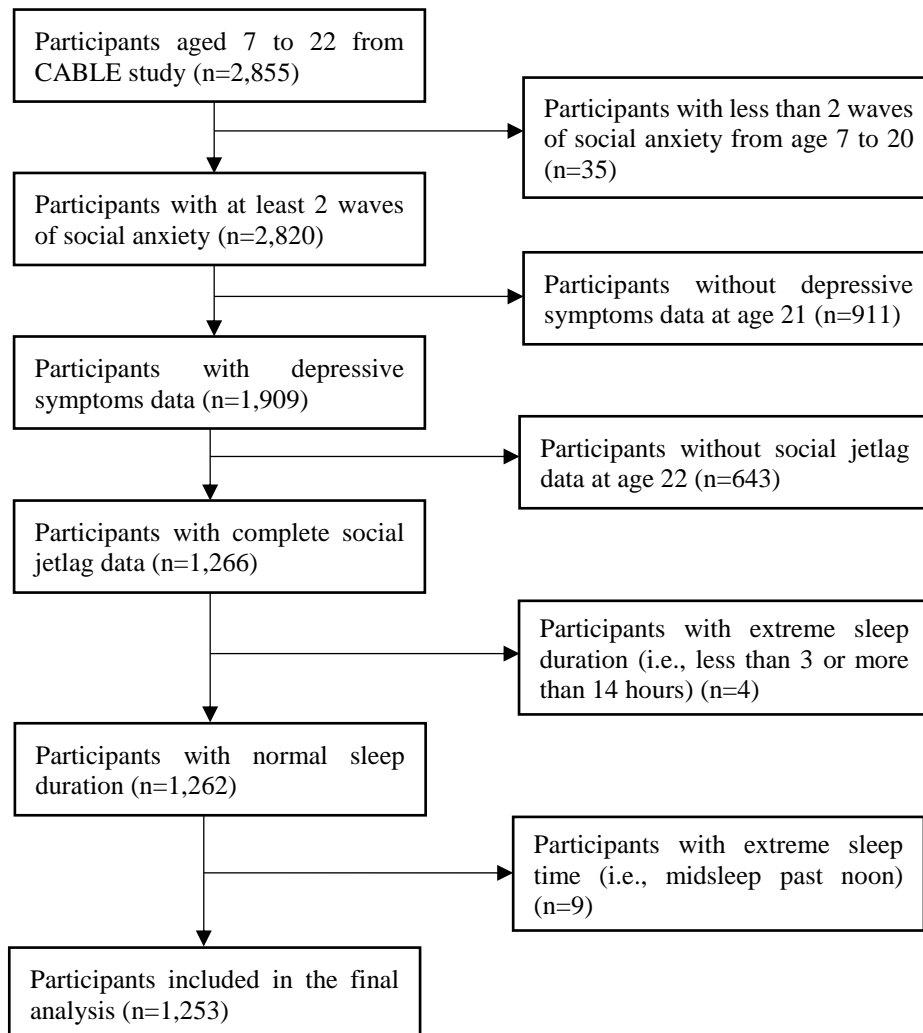


Figure 3 Study flowchart

4.1 Sample characteristics

Table 4 shows the sample characteristics of categorical data, whereas **Table 5** demonstrates the continuous variables characteristics. There were 1,253 participants in this study (608 males and 645 females). The most frequently reported paternal and maternal education level was university or above (59.55% and 52.56%, respectively). As for parental income, most of the participants' fathers and mothers earned a monthly income between NT\$40,000 and NT\$99,999 (53.47% and 53.07%, respectively). Proportions of family structure were 25.30% and 74.70%, respectively, for single-parent and two-parent families. The mean scores for family support and peer support were 17.28 and 44.29, respectively. Using a cutoff of 1-hour, 46.85% of the participants had social jetlag. Mean score for depressive symptoms was 8.98. 46.13% of the sample had prior history of social jetlag and mean score for prior depressive symptoms was 9.29. As for our main variables, the average scores for social anxiety from age 7 to age 20 ranged between 9.48 and 10.41. Social jetlag's normality was assessed using the Shapiro-Wilk test, and p -value less than 0.05 indicates non-normal distribution as shown in **Figure 4**.

Table 4 Sample characteristics of categorical variables

	n	%
Sex		
Male	608	48.52
Female	645	51.48
Paternal education level		
Junior high school or below	102	8.15
High school	404	32.29
University or above	745	59.55
Maternal education level		
Junior high school or below	94	7.52
High school	499	39.92
University or above	657	52.56
Paternal income		
≤NT\$39,999	170	13.57
NT\$40,000 to NT\$99,999	670	53.47
≥NT\$100,000	413	32.96
Maternal income		
≤NT\$39,999	149	11.89
NT\$40,000 to NT\$99,999	665	53.07
≥NT\$100,000	439	35.04
Family structure		
Single-parent household	317	25.30
Dual-parents household	936	74.70
Social jetlag		
<1-hour	666	53.15
≥1-hour	587	46.85
Prior social jetlag		
<1-hour	675	53.87
≥1-hour	578	46.13

Note. SD=standard deviation.

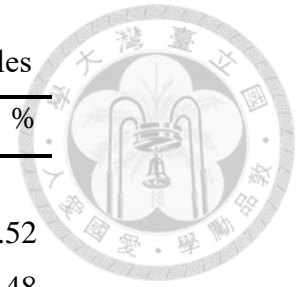
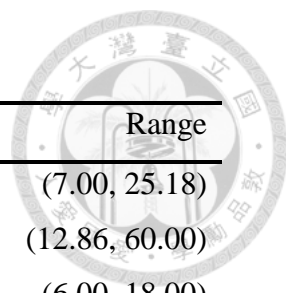


Table 5 Sample characteristics of continuous variables

	n	Mean	SD	Range
Family support	1,253	17.28	3.20	(7.00, 25.18)
Peer support	1,253	44.29	7.98	(12.86, 60.00)
Depressive symptoms	1,253	8.98	2.60	(6.00, 18.00)
Prior depressive symptoms	1,253	9.29	1.57	(6.07, 14.69)
Social anxiety				
Age 7	998	10.11	3.00	(7.00, 21.00)
Age 8	1,198	10.07	2.70	(7.00, 20.00)
Age 9	1,148	9.80	2.58	(7.00, 20.00)
Age 10	1,109	9.83	2.90	(7.00, 21.00)
Age 11	1,091	9.64	2.75	(7.00, 21.00)
Age 12	1,095	9.96	2.94	(7.00, 21.00)
Age 13	1,090	10.05	3.07	(7.00, 21.00)
Age 14	1,119	9.97	2.96	(7.00, 21.00)
Age 15	1,084	10.07	3.08	(7.00, 21.00)
Age 16	1,173	10.41	3.28	(7.00, 21.00)
Age 17	1,236	10.26	3.27	(7.00, 21.00)
Age 18	1,198	9.91	3.23	(7.00, 21.00)
Age 19	1,179	9.80	3.20	(7.00, 21.00)
Age 20	1,173	9.48	3.12	(7.00, 21.00)

Note. SD=standard deviation.

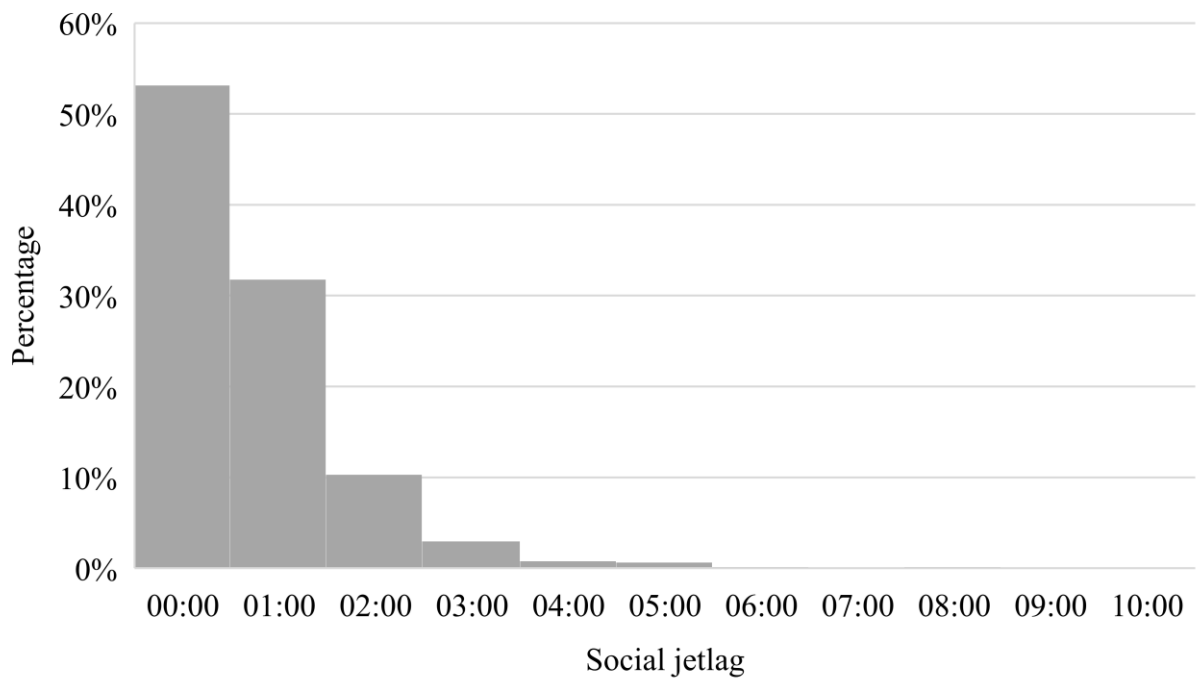
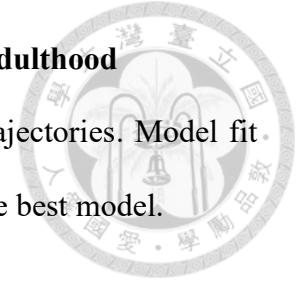


Figure 4 Distribution of social jetlag

4.2 Social anxiety trajectories from middle childhood to young adulthood

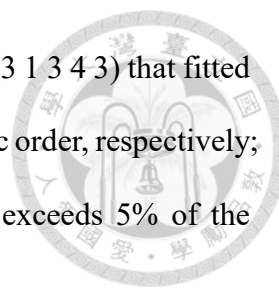
This section demonstrates the model selection for social anxiety trajectories. Model fit and model adequacy indices were compared to select and finalize the best model.



4.2.1 Model selection

Table 6 and **Table 7** were the model fit and adequacy statistics for our group-based trajectory model. The former table presented the Bayesian Information Criterion (BIC), log Bayes factor ($2\Delta\text{BIC}$), and Akaike Information Criterion (AIC) values for each converging model. At the same time, the latter showed the Average Posterior Probability (AvePP), Odds of Correct Classification (OCC), and group size of the final model.

As PROC TRAJ does not allow a polynomial order greater than four, we first modeled using two trajectory groups with the highest order (quartic). Then, we gradually increased the group numbers to six without adjusting the order. As exhibited, BIC values for two to six-group models were -38344.50 , -37955.85 , -37710.68 , -37623.36 , and -37507.01 , respectively. $2\Delta\text{BIC}$ decreased from the initial value of 777.30 to 174.64 , then increased slightly to 232.70 . AIC values gradually reduced from -38313.70 to -37414.61 . Although the six-group model had the smallest (nearest to zero) BIC and AIC value, sadly, its $2\Delta\text{BIC}$ was larger than its antecedent. In other words, the five-group model was superior to the six-group model. Therefore, the five-group model proceeded to model refinement.



The final model was concluded based on the polynomial order (3 1 3 4 3) that fitted the best. To note, 1, 3 and 4 represent the linear, cubic and quartic order, respectively; *p*-values for each order were significant; all five-group size exceeds 5% of the sample; and its BIC, 2 Δ BIC, AIC reflects a better fit.

Table 6 Model fit results

No. of groups	Polynomial order	BIC	2 Δ BIC	AIC	n >5% of the sample
2	44	-38344.50		-38313.70	Yes
3	444	-37955.85	777.30	-37909.65	Yes
4	4444	-37710.68	490.34	-37649.09	Yes
5	44444	-37623.36	174.64	-37546.36	No
6	444444	-37507.01	232.70	-37414.61	No
Final selection	31343	-37616.10	14.52	-37554.50	Yes

Notes. BIC = Bayesian Information Criteria; 2 Δ BIC = log Bayes factor; AIC = Akaike Information Criteria.

Furthermore, the average posterior probability of correct classification (AvePP) and Odds of correct classification (OCC) were evaluated to confirm model adequacy. AvePP ranged from 0.83 to 0.93, whereas OCC values were between 14.13 and 163.10. Both AvePP and OCC exceeded their respective threshold of 0.70 and 5. Membership assigned to each group was above 5% of the sample. Given the statistics, the five-group trajectory model that attained all requirements for model fitness and adequacy was selected.

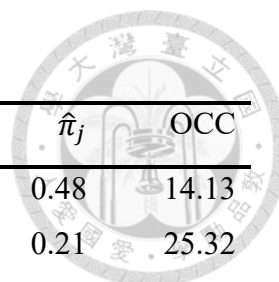


Table 7 Model adequacy results

No.	Label	n	%	AvePP	$\hat{\pi}_j$	OCC
Group 1	Low stable	616	49.16	0.93	0.48	14.13
Group 2	Moderate increasing	266	21.23	0.87	0.21	25.32
Group 3	Moderate to low	212	16.92	0.83	0.17	23.05
Group 4	High stable	92	7.34	0.90	0.08	98.90
Group 5	High increasing	67	5.35	0.90	0.05	163.10

Notes. AvePP = Average Posterior Probability; OCC = Odds of Correct Classification.

4.2.2 Patterns of social anxiety trajectories

Patterns and group proportions of five social anxiety trajectories from middle childhood to young adulthood (age 7 to age 20) were as demonstrated in **Figure 5**. Patterns exhibited include “low stable”, “moderate increasing”, “moderate to low”, “high stable”, and “high increasing”. The “low stable” group (n=616; 49.16%) revealed a decreasing trend of social anxiety from middle childhood to young adulthood. The “moderate increasing” group (n=266; 21.23%) posed relatively stable levels of social anxiety between age 7 and 11, and had slightly increased from then on. The “moderate to low” group (n=212; 16.92%) had a considerable decreased trend of social anxiety from beginning to end. The “high stable” group (n=92; 7.34%) exhibited a projectile-motion-like trend, which in other words, started with an increase in social anxiety levels from age 7 to age 12, then decreased rapidly, especially between age 13 and age 16. The “high increasing” group (n=67; 5.35%) displayed substantial increase throughout the course, with a peak at age 17 then a slight decrease between age 17 to age 20.

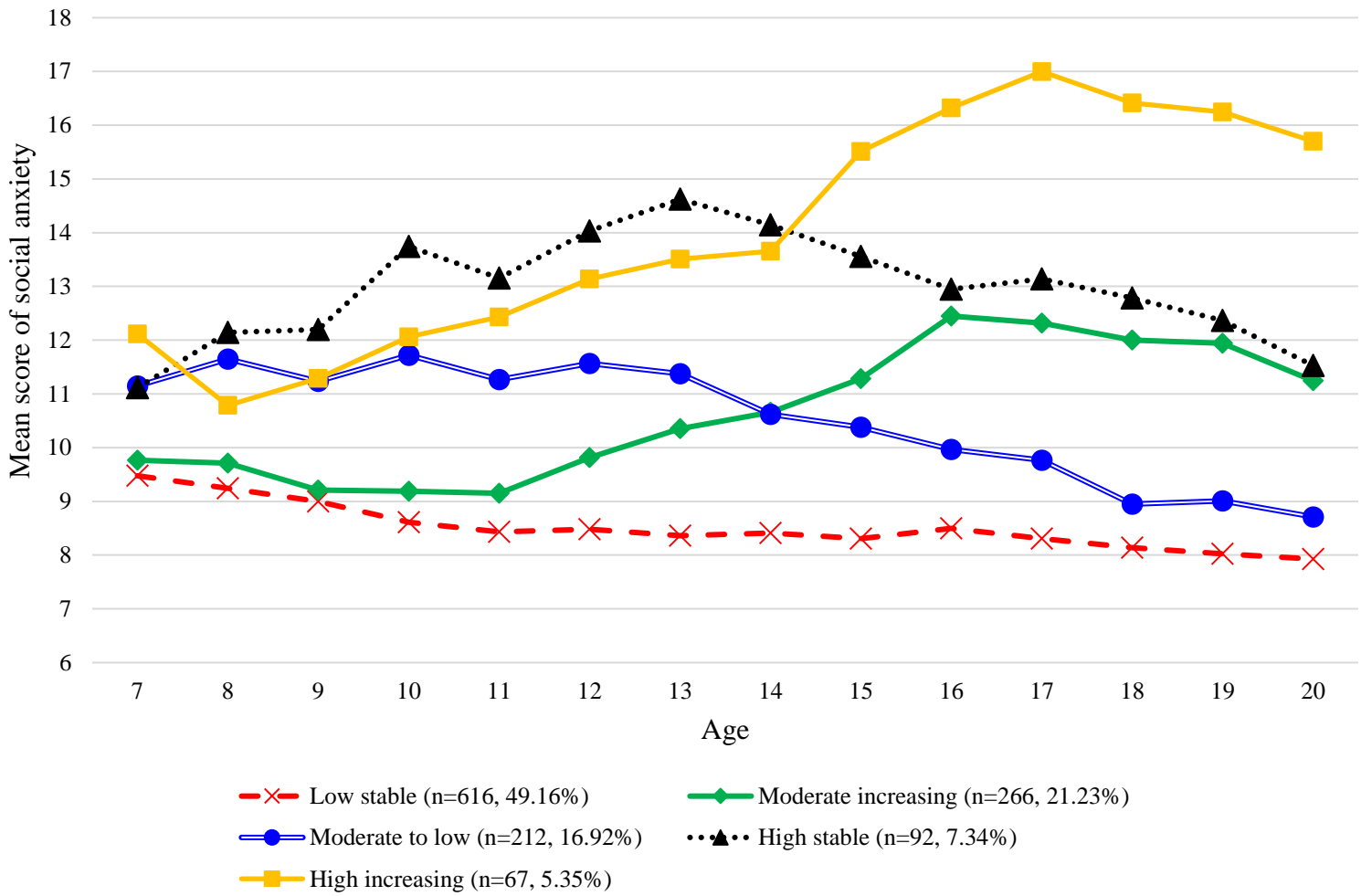


Figure 5 Social anxiety trajectories from age 7 to age 20

4.2.3 Characteristics of social anxiety trajectories

Table 8 revealed the characteristics of the five distinct trajectories of social anxiety.

According to the Chi-squared test results, the distribution of categorical variables including paternal education, maternal education, paternal income, maternal income, family structure, and prior social jetlag did not differ significantly among trajectory groups. Social jetlag is marginally significant among social anxiety trajectory groups ($p < 0.10$). Significant sex differences in social anxiety trajectories were discovered ($p < 0.001$). The proportion difference is significant between “low stable” and all other groups.

For continuous variables, the Kruskal-Wallis H test revealed significant differences in family support, peer support, depressive symptoms and prior depressive symptoms scores among trajectories ($p < 0.001$). Subsequent posthoc Dunn tests were performed to identify statistically significant groups. Results were as follows: (1) individuals in the “low stable” group had significantly higher scores in both family support and peer support than the other groups; (2) participants in the “high increasing” group had significantly higher levels of prior depressive symptoms and depressive symptoms than the remaining groups.

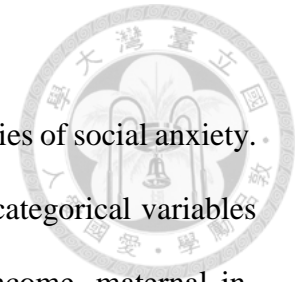


Table 8 Sociodemographic characteristics of social anxiety trajectories

	Low stable	Moderate increasing	Moderate to low	High stable	High increasing	χ^2
	n (%)	n (%)	n (%)	n (%)	n (%)	
Sex						23.87***
Male	335 (55.10)	129 (21.22)	87 (14.31)	35 (5.76)	22 (3.62)	
Female	281 (43.57)	137 (21.24)	125 (19.38)	57 (8.84)	45 (6.98)	
Paternal education level						11.30
Junior high school or below	48 (47.06)	24 (23.53)	11 (10.78)	13 (12.75)	6 (5.88)	
High school	201 (49.75)	76 (18.81)	80 (19.80)	25 (6.19)	22 (5.45)	
University or above	366 (49.13)	166 (22.28)	120 (16.11)	54 (7.25)	39 (5.23)	
Maternal education level						6.62
Junior high school or below	39 (41.49)	22 (23.40)	18 (19.15)	10 (10.64)	5 (5.32)	
High school	245 (49.10)	97 (19.44)	89 (17.84)	41 (8.22)	27 (5.41)	
University or above	330 (50.23)	147 (22.37)	104 (15.83)	41 (6.24)	35 (5.33)	
Paternal income						7.10
≤NT\$39,999	83 (48.82)	30 (17.65)	31 (18.24)	15 (8.82)	11 (6.47)	
NT\$40,000 to NT\$99,999	337 (50.30)	133 (19.85)	112 (16.72)	50 (7.46)	38 (5.67)	
≥NT\$100,000	196 (47.46)	103 (24.94)	69 (16.71)	27 (6.54)	18 (4.36)	
Maternal income						12.92
≤NT\$39,999	75 (50.34)	19 (12.75)	31 (20.81)	10 (6.71)	14 (9.40)	
NT\$40,000 to NT\$99,999	330 (49.62)	147 (22.11)	107 (16.09)	50 (7.52)	31 (4.66)	
≥NT\$100,000	211 (48.06)	100 (22.78)	74 (16.86)	32 (7.29)	22 (5.01)	

Note. χ^2 = Chi-squared test.

***p<0.001.

Table 8 Sociodemographic characteristics of social anxiety trajectories (continued)

	Low stable	Moderate increasing	Moderate to low	High stable	High increasing	χ^2
	n (%)	n (%)	n (%)	n (%)	n (%)	
Family structure						3.98
Single-parent household	462 (49.36)	207 (22.12)	156 (16.67)	66 (7.05)	45 (4.81)	
Dual-parents household	154 (48.58)	59 (18.61)	56 (17.67)	26 (8.20)	22 (6.94)	
Social jetlag						8.13†
<1-hour	346 (51.95)	140 (21.02)	109 (16.37)	38 (5.71)	33 (4.95)	
≥1-hour	270 (46.00)	126 (21.47)	103 (17.55)	54 (9.20)	34 (5.79)	
Prior social jetlag						2.12
<1-hour	332 (49.19)	138 (20.44)	120 (17.78)	46 (6.81)	39 (5.78)	
≥1-hour	284 (49.13)	128 (22.15)	92 (15.92)	46 (7.96)	28 (4.84)	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	χ^2
Family support	17.74 (3.23)	17.09 (2.97)	17.13 (3.33)	15.82 (2.86)	16.42 (2.88)	42.30***
Peer support	45.49 (8.07)	43.10 (7.51)	44.16 (7.94)	41.38 (7.99)	42.31 (7.03)	44.69***
Depressive symptoms	8.07 (2.19)	10.27 (2.43)	8.71 (2.38)	10.36 (2.94)	11.25 (2.65)	219.59***
Prior depressive symptoms	8.42 (1.24)	9.92 (1.26)	9.74 (1.31)	10.83 (1.23)	11.24 (1.33)	452.24***

Notes. χ^2 = Chi-squared test or Kruskal-Wallis H test.

†p<0.10; ***p<0.001.



4.3 Bivariate association between study variables

4.3.1 Association between continuous variables and social jetlag

As shown by the Mann-Whitney U test results in **Table 9**, the social jetlag ≥ 1 -hour group had a significantly lower mean score for family support and a higher mean score for subsequent depressive symptoms. Notably, the former group had significantly lower scores in family support ($p < 0.05$) and higher scores in both depressive symptoms and prior depressive symptoms ($p < 0.05$) than the < 1 -hour group.

Table 9 Bivariate association between continuous covariates with social jetlag

	SJL < 1 h			SJL ≥ 1 h			Z
	n	Mean	SD	n	Mean	SD	
Family support	666	17.47	3.18	587	17.08	3.21	5.07*
Peer support	666	44.53	7.83	587	44.01	8.14	0.70
Depressive symptoms	666	8.78	2.43	587	9.22	2.76	5.62*
Prior depressive symptoms	666	9.19	1.52	587	9.40	1.61	6.29*

Notes. SJL = social jetlag; Z= Mann-Whitney U test.

* $p < 0.05$.

4.3.2 Association between categorical variables and social jetlag

Table 10 demonstrates the bivariate association between categorical covariates and social jetlag. Participants with <1-hour and \geq 1-hour of social jetlag differed significantly by maternal education level ($p<0.05$), paternal income ($p<0.05$), family structure ($p<0.05$), and prior social jetlag ($p<0.001$). Paternal education level displayed marginal significance ($p<0.10$) between <1-hour and \geq 1-hour of social jetlag groups. **Table 11** exhibits the bivariate association between social anxiety trajectory groups and social jetlag. Results reported marginal significance in social jetlag ($p<0.10$) between trajectory groups.

Table 10 Bivariate association between categorical covariates with social jetlag

	SJL <1h	SJL ≥1h	
	n (%)	n (%)	
Sex			1.60
Male	312 (46.85)	296 (50.43)	
Female	354 (53.15)	291 (49.57)	
Paternal education level			5.14†
Junior high school or below	51 (7.68)	51 (8.69)	
High school	198 (29.82)	206 (35.09)	
University or above	415 (62.50)	330 (56.22)	
Maternal education level			7.43*
Junior high school or below	54 (8.12)	40 (6.84)	
High school	242 (36.39)	257 (43.93)	
University or above	369 (55.49)	288 (49.23)	
Paternal income			8.17*
≤NT\$39,999	88 (13.21)	82 (13.97)	
NT\$40,000 to NT\$99,999	335 (50.30)	335 (57.07)	
≥NT\$100,000	243 (36.49)	170 (28.96)	
Maternal income			3.46
≤NT\$39,999	76 (11.41)	73 (12.44)	
NT\$40,000 to NT\$99,999	341 (51.20)	324 (55.20)	
≥NT\$100,000	249 (37.39)	190 (32.37)	
Family structure			4.61*
Single-parent household	514 (77.18)	422 (71.89)	
Dual-parents household	152 (22.82)	165 (28.11)	
Prior social jetlag			45.23***
<1-hour	418 (62.76)	257 (43.78)	
≥1-hour	248 (37.24)	330 (56.22)	

Notes. SJL = social jetlag; χ^2 = Chi-squared test.

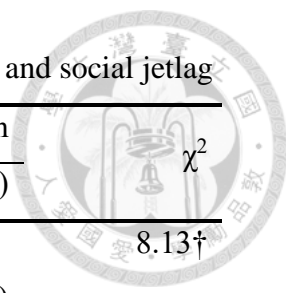
†p<0.10; *p<0.05; *** p<0.001.

Table 11 Bivariate association between social anxiety trajectories and social jetlag

	SJL <1h	SJL ≥1h
	n (%)	n (%)
Social anxiety trajectories		
Low stable	346 (51.95)	270 (46.00)
Moderate increasing	140 (21.02)	126 (21.47)
Moderate to low	109 (16.37)	103 (17.55)
High stable	38 (5.71)	54 (9.20)
High increasing	33 (4.95)	34 (5.79)

Notes. SJL = social jetlag; χ^2 = Chi-squared test.

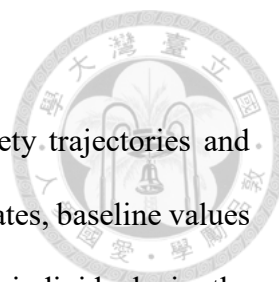
†p < 0.10.



4.4 Association between social anxiety trajectories and social jetlag

Table 12 shows the results of the association between social anxiety trajectories and social jetlag, as well as the mediation results on whether depressive symptoms mediated the association between social anxiety trajectories and social jetlag after controlling for relevant covariates (i.e., sex, parental education, parental income, family structure, family support, peer support, prior depressive symptoms, and prior social jetlag).

Model 1 of **Table 12** demonstrates the total effect of social anxiety trajectories on social jetlag (c_1, c_2, c_3, c_4 path). After controlling for covariates and baseline values of depressive symptoms and social jetlag, the “high stable” social anxiety trajectory group was marginally significant with social jetlag (c_3 path: OR = 1.62, $p=0.06$). This indicates that the odds of developing social jetlag were 62% higher in the “high stable” group than in the “low stable” group. In other words, socially anxious individuals in the “high stable” group are more likely to develop social jetlag than those in the “low stable” group. In contrast, there was no significant difference in the odds of developing social jetlag between individuals in the “moderate increasing”, “moderate to low”, or “high increasing” compared to those who belonged to the “low stable” group. R-squared for model 1 was 0.07, indicating small effect size.



4.5 Depressive symptoms as a mediator

Model 2 in **Table 12** presents the association between social anxiety trajectories and depressive symptoms (a_1, a_2, a_3, a_4 path). After controlling for covariates, baseline values of both depressive symptoms and social jetlag, socially anxious individuals in the “moderate increasing” (a_1 path: $\beta=0.98, p<0.001$) and “high increasing” (a_4 path: $\beta=0.83, p<0.01$) group had significantly higher levels of depressive symptoms than those in the “low stable group,” respectively. Individuals with “moderate to low” social anxiety trajectory (a_2 path: $\beta=-0.44, p<0.05$) had significantly lower levels of depressive symptoms than the reference group.

These results imply that there is a statistically significant relationship between “moderate increasing”, “moderate to low”, and “high increasing” social anxiety trajectories and depressive symptoms, and such social anxiety trajectories coefficients predicted depressive symptoms scores. On average, individuals in the “moderate increasing” and “high increasing” groups reported depressive symptoms score that is 0.98 points and 0.83 points higher than the “low stable” group, respectively. Contrarily, the “moderate to low” group reported depressive symptoms score that is 0.44 points lower than the “low stable” group. On the other hand, the relationship between “high stable” trajectory pattern and depressive symptoms was nonsignificant. R-squared for model 2 was 0.34, indicating medium effect size.

Model 3 in **Table 12** reveals both the association between depressive symptoms and social jetlag (b path); and the association between social anxiety trajectories on social jetlag (c'_1, c'_2, c'_3, c'_4 path) after controlling for depressive symptoms and other covariates. As hypothesized, depressive symptoms were significantly associated with social jetlag. In

particular, individuals with higher levels of depressive symptoms are more likely to have social jetlag (*b* path: OR=1.07, $p<0.05$). After adjustment for depressive symptoms and other covariates, only the association of the “high stable” (*c*'₃ path: OR = 1.59, $p=0.07$) group and social jetlag remained marginally significant.

The indirect effects of social anxiety trajectories on social jetlag through depressive symptoms (*a*b* path) were exhibited at **Table 13**. Depressive symptoms significantly mediated the association between social anxiety trajectories and social jetlag, as 95% bootstrapped confidence interval did not include 1: “moderate increasing” ($ab=1.06$, 95% bootstrap CI= 1.009, 1.133); “moderate to low” ($ab=0.97$, 95% bootstrap CI= 0.933, 0.999); and “high increasing” ($ab=1.05$, 95% bootstrap CI= 1.001, 1.142). These results indicated that, compared to those with “low stable” trajectory, those with “moderate increasing” and “high increasing” pattern of social anxiety had higher odds of having social jetlag through depressive symptoms. On the other hand, those with “moderate to low” pattern of social anxiety had lower odds of developing social jetlag through depressive symptoms. Proportion mediated of “moderate increasing”, “moderate to low”, and “high increasing” social anxiety trajectories on social jetlag through depressive symptoms were 0.96, 0.80, and 0.90, respectively.

Statistical diagram for the total effect of “moderate increasing”, “moderate to low”, “high stable” and “high increasing” social anxiety trajectories on social jetlag; and the indirect effect of “moderate increasing”, “moderate to low”, “high stable” and “high increasing” social anxiety trajectories on social jetlag through depressive symptoms were displayed in **Figure 6**.


Table 12 Regression coefficients for mediation analyses

	Model 1: Social jetlag			Model 2: Depressive symptoms			Model 3: Social jetlag		
	Path	OR	95% CI	Path	β	SE	Path	OR	95% CI
Constant		0.26*	—		1.46*	0.65		0.23*	0.07-0.80
Sex (<i>ref.</i> : male)									
Female		0.82	0.63-1.06		0.12	0.14		0.81	0.62-1.05
Paternal education level									
(<i>ref.</i> : junior high or below)									
High school		1.04	0.65-1.68		-0.02	0.16		1.12	0.82-1.51
University or above		0.94	0.57-1.55		0.07	0.27		0.93	0.56-1.54
Maternal education level									
(<i>ref.</i> : junior high or below)									
High school		1.45	0.89-2.37		-0.10	0.15		1.13	0.84-1.51
University or above		1.30	0.76-2.21		-0.28	0.28		1.32	0.77-2.25
Paternal income									
(<i>ref.</i> : ≤NT\$39,999)									
NT\$40,000-NT\$99,999		1.28	0.84-1.97		-0.04	0.22		0.64*	0.42-0.97
≥NT\$100,000		0.82	0.48-1.38		-0.24	0.23		1.30	0.85-2.01
Maternal income									
(<i>ref.</i> : ≤NT\$39,999)									
NT\$40,000-NT\$99,999		0.87	0.55-1.39		-0.04	0.22		1.35	0.89-2.05
≥NT\$100,000		1.17	0.67-2.05		-0.17	0.24		0.88	0.56-1.40
Family structure									
(<i>ref.</i> : Single-parent)									
Dual-parents household		1.20	0.91-1.58		-0.00	0.15		1.20	0.91-1.58
Family support		1.00	0.95-1.04		0.02	0.02		1.00	0.95-1.04
Peer support		1.00	0.98-1.02		-0.00	0.01		1.00	0.98-1.02
Social anxiety trajectories									
(<i>ref.</i> : low stable)									
Moderate increasing	<i>c</i>	1.10	0.79-1.54	<i>a</i>	0.98***	0.17	<i>c'</i>	1.04	0.74-1.45
Moderate to low		1.21	0.86-1.72		-0.44*	0.18		1.25	0.88-1.77
High stable		1.62†	0.97-2.70		0.31	0.27		1.59†	0.95-2.67
High increasing		1.17	0.65-2.10		0.83**	0.31		1.11	0.62-2.00
Depressive symptoms		—	—		—	—	<i>b</i>	1.07*	1.01-1.13
Prior depressive symptoms		1.07	0.97-1.17		0.83***	0.05		1.01	0.91-1.12
Prior social jetlag		2.09***	1.65-2.65		-0.06	0.13		2.11***	1.66-2.67

Notes. All models were controlled for sex, parental education, parental income, family structure, family support, peer support, prior depressive symptoms, and prior social jetlag. OR = odds ratio; SE = standard error; CI = confidence interval; *ref.* = reference group.

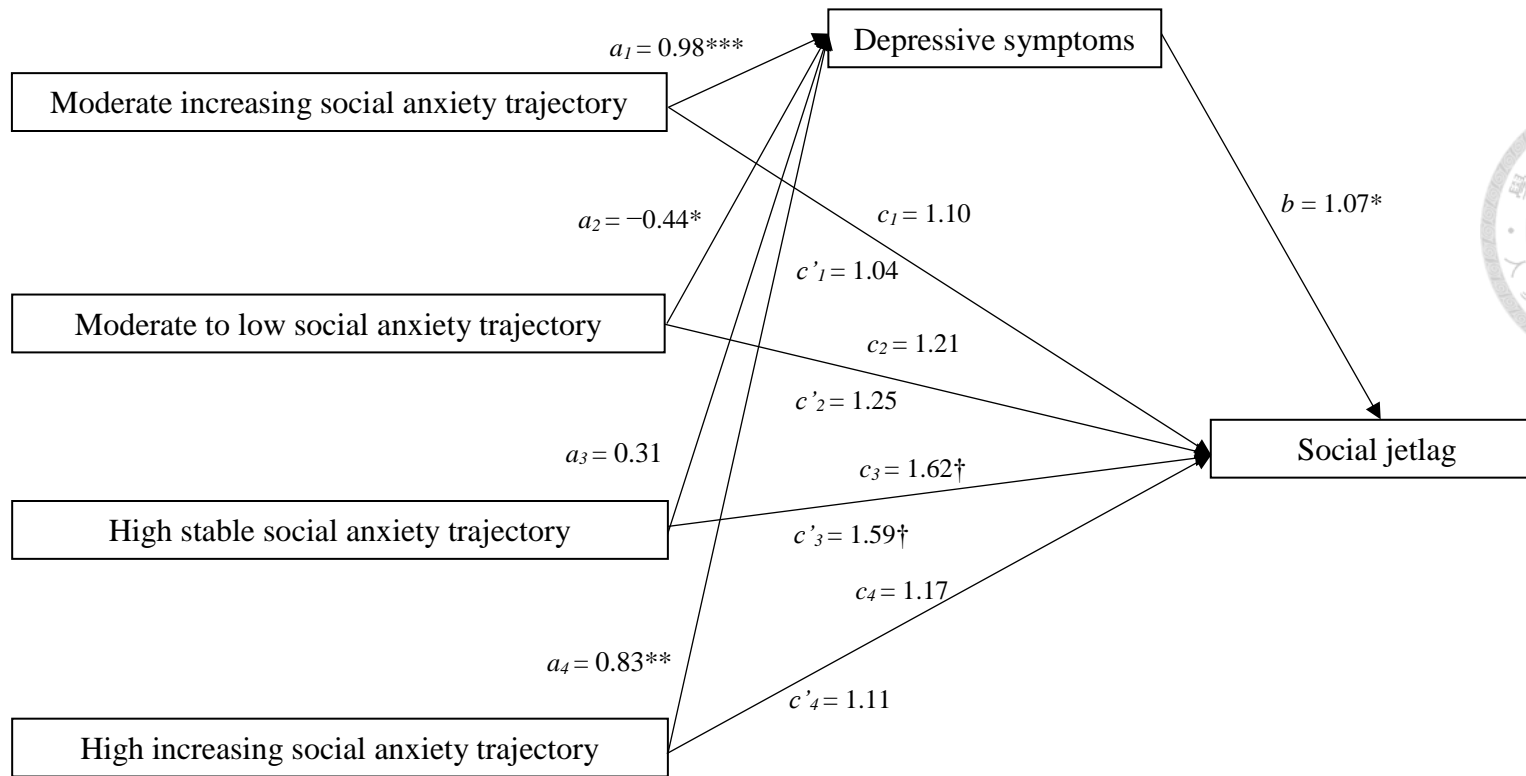
†*p*<0.10; **p*<0.05; ** *p*<0.01; ****p*<0.001.

Table 13 Indirect effects of social anxiety trajectories on social jetlag



	OR	SE	95% Bootstrap CI
Moderate increasing	1.06	1.03	1.009, 1.133
Moderate to low	0.97	1.02	0.933, 0.999
High stable	1.02	1.02	0.981, 1.077
High increasing	1.05	1.03	1.001, 1.142

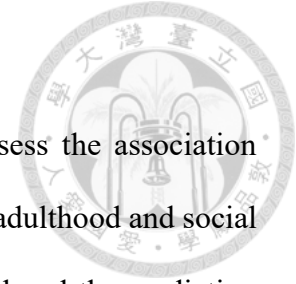
Notes. OR = odds ratio; SE = standard error; CI = confidence interval.



Notes $^\dagger p < 0.10$; $* p < 0.05$; $** p < 0.01$; $*** p < 0.001$

Figure 6 Path diagrams for total effect and indirect effect of social anxiety trajectories on social jetlag through depressive symptoms

Chapter 5 Discussion

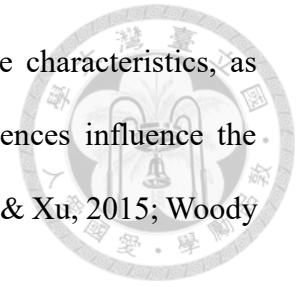


To the best of my knowledge, the current study is the first to assess the association between social anxiety trajectories from middle childhood to young adulthood and social jetlag in early adulthood. On top of that, no prior studies have explored the mediating effects of depressive symptoms on social anxiety trajectory patterns and social jetlag. This study identified five distinct social anxiety trajectories. One of the trajectory, specifically, the high stable pattern, had a marginal significant relationship with social jetlag. Findings also demonstrated that depressive symptoms mediated the associations between social anxiety trajectories and social jetlag.

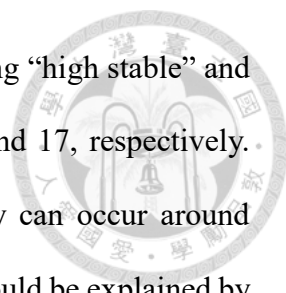
5.1 Social anxiety trajectories from middle childhood to young adulthood

The results successfully answered all three of this study's research questions. First of all, in line with previous studies, current findings demonstrated that the heterogeneity in the developmental course of social anxiety as five trajectory patterns of social anxiety were identified in this study: (1) "low stable"; (2) "moderate increasing"; (3) "moderate to low"; (4) "high stable"; (5) "high increasing". The patterns of trajectories supported the author's expectation of discriminating around five to six trajectory groups. Also, as anticipated, the "low stable" group that began with a low level of social anxiety and decreased over time represented the majority (49.16%); and the "high increasing" group was the least of all (5.35%). The latter group initially had high social anxiety from the start. It showed a tremendous increasing trend till late adolescence of age 17, then leveling off from then till young adulthood. Group proportions were not similar to prior longitudinal studies. The largest social anxiety trajectory for other studies was stable medium, stable high or moderate decreasing, while the smallest were stable very high, low increasing, and high changing (Broeren et al., 2012; Marmorstein et al., 2010; Miers et al., 2013). These

differences could be attributed to the cultural variations in sample characteristics, as suggested by two meta-analyses, where cultural and ethnic differences influence the manifestation of social anxiety between Asians and European (Krieg & Xu, 2015; Woody et al., 2015).



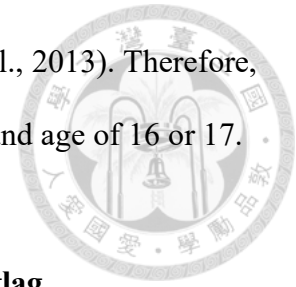
Five social anxiety trajectories found in this study exhibited either decreasing, waxing and waning, or increasing patterns across childhood, adolescence, and young adulthood. The “low stable” and “moderate to low” patterns gradually decrease from the start. In contrast, the “moderate increasing”, “high stable”, and “high increasing” commonly increase then decrease at a certain age. Particularly, the “moderate to low”, and “high stable” trajectories seemed to decrease considerably, as opposed to a slight decline (Broeren et al., 2012; Miers et al., 2013). However, the drastic decreasing patterns and Marmorstein et al. (2010) were much alike. Compared to former social anxiety trajectories studies, the changing patterns in the “moderate increasing” and “high increasing” trajectory were, in contrast, to their relatively stable or slight increase patterns (Broeren et al., 2012; Miers et al., 2013). Please note that although one of this study trajectory was named “high stable”, the word “stable” does not imply that both were entirely unchanging. Instead, stability is meant by fluctuating within the same range. These observed differences could be explained by the study’s longer span of analysis, which was 14 years, as opposed to 8 years in other studies (Broeren et al., 2012; Marmorstein et al., 2010; Van Oort et al., 2009). This highlights this study’s strengths of analyzing longer age spans of socially anxious individuals, up to 14 years, and across three periods.



Based on the trajectory figure, social anxiety levels were rising among “high stable” and “high increasing” individuals since age 8, then peaked at age 13 and 17, respectively. These upward trends substantiate prior findings that social anxiety can occur around young children. The peak attained at age 13 by “high stable” group could be explained by the shift from elementary school to junior high school among students with an already high level of social anxiety. This transition can be emotionally and socially challenging to socially anxious individuals as they are forced to adapt to new environments and unfamiliar peers. Another peak at age 16 among “moderate increasing” and 17 among “high increasing” groups could indicate another uneasy adaptation into senior high school among those with moderate or high social anxiety levels. School transfer difficulties can be supported by Nowland and Qualter's (2020) study, where students with social anxiety experience heightened concerns about school transitions.

Also, interestingly, all five trajectories experienced a decline in social anxiety levels at age 16 or 17. Simultaneous reduction of social anxiety could be related to the emerging use of the internet and smartphones around 2010, or they gained better social skills over time. The former explanation was credible as prior studies have found that socially anxious individuals prefer online communication (Caplan, 2003). The internet has allowed them to switch from actual and face-to-face communications to virtual communication and may be a medium for them to connect with others comfortably (i.e., less fear and negative thinking) (Hutchins et al., 2021; Shepherd & Edelmann, 2005; J. Y. Yen et al., 2012). On the other hand, the latter explanation of increased social skills could be explained in terms of physiological development. As an individual's brain undergoes major development during adolescence, the prefrontal cortex's maturation

enhances logical reasoning skills and emotion regulation (Arain et al., 2013). Therefore, physiological changes could partly explain the decreasing trend around age of 16 or 17.

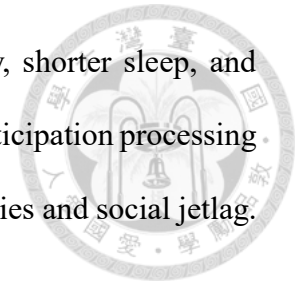


5.2 Associations between social anxiety trajectories and social jetlag

Results from binary logistic regression partly align with the study's second hypothesis suggesting that social anxiety trajectories from middle childhood to young adulthood were associated with social jetlag during young adulthood. Surprisingly, the marginal significance of the total effects was restricted to only highly stable social anxiety. This unique relationship aligns with Buckner et al. (2008) study, which found that social anxiety was positively related to insomnia. Indeed, one may argue that the link between social anxiety and insomnia does not necessarily mean a similar linkage to social jetlag. However, considering the high co-existence of social jetlag and insomnia, it is reasonable to assert that people with social anxiety, too, suffer from social jetlag. Additionally, it is possible that these high and chronic socially anxious individuals could have gotten used to the irregular sleep induced by social anxiety and were likely to continue the practice of such unstable circadian patterns during young adulthood.

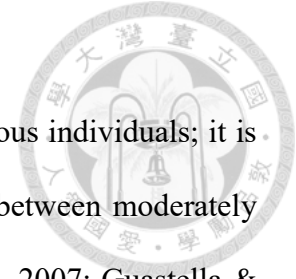
Theoretically, according to Clark and Wells' (1995) cognitive-behavioral model of social anxiety, anticipation processing could account for the relationship between social anxiety trajectories and social jetlag. In the case of socially anxious individuals, anticipation processing may involve excessive worry about future social situations, rumination on past negative social experiences, and a preoccupation with negative self-evaluations (Vassilopoulos, 2004). These distorted cognitive processes may increase physiological arousal and heightened vigilance, further exacerbating sleep problems (Buckner et al., 2008). As expected, a meta-analysis by Clancy et al. (2016) found that anticipatory worry

and rumination were associated with increased sleep onset latency, shorter sleep, and poorer sleep quality. Based on these findings, it is conceivable that anticipation processing may play an essential role in the link between social anxiety trajectories and social jetlag.



Besides the aforementioned cognitive factors, study findings could also be supported using the homeostatic regulation of sleep. Sleep disturbance has been the hallmark feature of an anxiety disorder (Fuller et al., 1997), which could lead to insomnia and sleep deprivation, so socially anxious individuals may extend sleep to compensate for lost sleep (Deboer, 2018). In the case of young adults with social anxiety, especially those working and increasing the amount of sleep during workdays may not be feasible, one could opt for a long weekend catch-up sleep as a strategy to reduce sleep propensity. Consequently, an inconsistency between weekday and weekend sleep patterns among socially anxious people could be established. These statements agree with a large-scale biobank study by Wainberg and associates (2021), who found sleep pattern differences in mentally disordered subjects. Based on this evidence, asserting the association between social anxiety trajectories and social jetlag is logical.

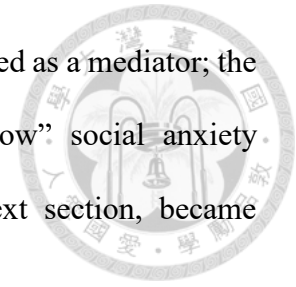
Although previous evidence of social anxiety trajectories and social jetlag is lacking, this study's justification is not groundless. What the author reasoned above is consistent with earlier works like Ehlers and co-authors' (1988) social zeitgeber (i.e., social rhythm) theory which posits that disruption of social rhythms like social interaction with others could damage the circadian rhythm, and Shear and colleagues' (1994) who identified low social rhythmicity among anxiety disordered people. Overall, it is credible that negative cognitive style and irregular social rhythm disrupt sleep and circadian clock in individuals with social anxiety, thus increasing the risk of social jetlag.



As we all know, sleep problems are prominent among socially anxious individuals; it is not surprising that the study found such a significant relationship between moderately increasing social anxiety trajectories and social jetlag (Alfano et al., 2007; Guastella & Moulds, 2007; Ramsawh et al., 2009). As per prior studies, people with social anxiety are prone to intrusive thoughts and constant worrying, which impact their ability to relax and mentally wind down before bedtime (Brozovich & Heimberg, 2008; Harvey & Greenall, 2003; M. B. Stein et al., 1993). Individuals with persistently high social anxiety could experience frequent difficulty falling asleep or staying asleep due to heightened anxiety and distress (Buckner et al., 2008). Therefore, though only marginally significant, it is unsurprising that the association between social anxiety trajectories and social jetlag was established in this study.

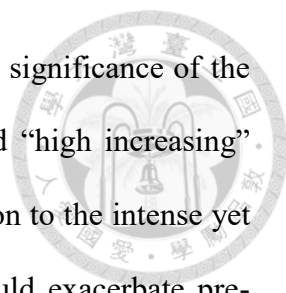
Unexpectedly, the association between “high increasing” social anxiety trajectories and social jetlag was not significant in the current study. Such a finding could be due to the small group proportion, which limits the detection of statistical significance. Future research should consider increasing the sample proportion of such high and increasingly socially anxious individuals. As for the nonsignificant associations between “moderate increasing” and “high increasing” social anxiety trajectories and social jetlag, the author speculates that a moderate social anxiety trajectory alone was insufficient to initiate subsequent social jetlag during young adulthood. Such speculation is based on the fact that although sleep disturbance in social anxiety is highly discussed, it is, in fact, not a core diagnostic criterion of social anxiety, unlike mental disorders like generalized anxiety disorder (GAD), post-traumatic stress disorder (PTSD), and depression (American Psychiatric Association, 2013; Mellman, 2006). Moreover, the author’s

conjecture made more sense when depressive symptoms were included as a mediator; the relationship between “moderate increasing” and “moderate to low” social anxiety trajectories and social jetlag, which will be discussed in the next section, became significant.



5.3 Mediating effect of depressive symptoms on the relationship between social anxiety trajectories and social jetlag

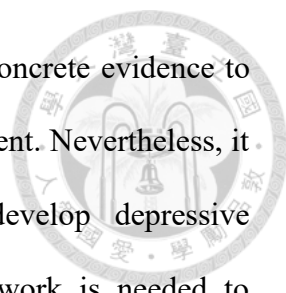
The current study is the first to report that depressive symptoms could act as a mediator between social anxiety trajectories and social jetlag. The current findings showed that depressive symptoms mediated the relationship between social anxiety trajectories and social jetlag. Specifically, the “moderate increasing” and “high increasing” social anxiety trajectory was associated with higher depressive symptoms, increasing the likelihood of social jetlag. In addition, the “moderate to low” social anxiety trajectory was related to lower depressive symptoms, decreasing the odds of having social jetlag. Notably, the mediating effects found in this study are consistent with one of the few relevant works by Buckner and colleagues (2008) and Bogusch et al. (2016), where social anxiety is positively associated with depressive symptoms and that depressive symptoms are negatively associated with sleep. It is not surprising that the study found such significance, as social anxiety tends to co-occur with depressive symptoms, and both social anxiety and depressive symptoms have been linked to sleep disturbances, thus, likely to develop social jetlag. However, the question of why this mediation is present for “moderate increasing”, “moderate to low” and “high increasing” social anxiety trajectories but not “high stable” patterns remains open.



Possible explanations of each social anxiety trajectory regarding the significance of the mediator are discussed accordingly. For “moderate increasing” and “high increasing” social anxiety trajectories, one possible explanation is that, in addition to the intense yet chronic levels of social anxiety, elevated depressive symptoms could exacerbate pre-existing negative thinking, sleep disturbance, and irregularity, thus, further perpetuating the misalignment of social and biological time. This could be further confirmed by physiological evidence that discovered alterations in the suprachiasmatic nucleus (SCN) of the hypothalamus, a crucial part of controlling the human biological clock, among depressive people, leading to circadian rhythm disruption (Vadnie & McClung, 2017; Zhou et al., 2001).

“Moderate to low” social anxiety trajectory was associated with decreased risk of social jetlag through lower depressive symptoms. Along with the downtrend of social anxiety levels, lower depressive symptoms may be related to less worrying and ruminating, fewer sleep disturbances, and fewer issues with social jetlag. Results were partly congruent with past studies showing that excessive worry and rumination affiliated with psychiatric disorders are frequently connected to poor sleep (Carney et al., 2006; Tousignant et al., 2019). These individuals were possibly more able to manage pre-sleep negative thoughts, reducing their odds of disrupted sleep and social jetlag. Also, the author supposed the same significance for “high stable” trajectory, but the outcome was unexpected. This could be attributable to the small group size, as mentioned previously.

Keep in mind that the results were unique to this study, and careful interpretation is required. Further studies with a larger sample are suggested to validate these apparent results. Perhaps with a larger sample size, outcomes of the nonsignificant trajectory would



be turned around. Lastly, the author attempted to search for more concrete evidence to support the study hypothesis; sadly, no mediational finding was evident. Nevertheless, it is certainly possible that socially anxious individuals may develop depressive symptomatology, which then leads to social jetlag. Prospective work is needed to investigate the complex interplay between social anxiety trajectories, depressive symptoms, and social jetlag. Understanding the relationship between these factors may be vital to developing effective prevention and treatment strategies for social jetlag among socially anxious individuals.

5.4 Study strengths and limitations

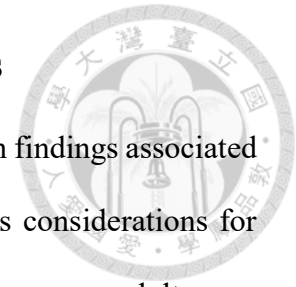
Both strengths and limitations in this study are noteworthy. First of all, this study identified long-term trajectories of social anxiety across childhood aged 7 to young adulthood aged 20 based on yearly evaluation. Indeed, a thorough search of social anxiety trajectories-related literature revealed that Miers and colleagues' (2013) study also analyzed individuals with an impressive age range of 9 to 21. However, it is essential to note that the mentioned research relied on cohort sequential design using merely four annual assessments and a smaller sample of around 330 people. Comparatively, study results were based upon actual data that are measured annually and stretched over 14 years. Also, noticeably, the study sample size was considered larger than most of the relevant literature. Secondly, as far as it is known, this is the first Asian and Taiwanese study to delineate specifically social anxiety trajectories from middle childhood to young adulthood and further suggest their marginal significant association with social jetlag during early adulthood. Thirdly, this investigation was the first to unravel the triangular relationship between social anxiety trajectories, depressive symptoms, and social jetlag.

Study results shed light on the impact of social anxiety trajectories on social jetlag through the mediating role of depressive symptoms.



Undoubtedly, the empirical research conducted had several limitations. First, the study sample was restricted to participants from northern Taiwan, specifically Taipei City and Hsinchu County, which accounts for only a small part of the northmost region of Taiwan. Thus, the generalizability of research findings is limited. Second, study data relied on self-reported questionnaires as an indicator of social anxiety and social jetlag. Data constraints create a potential source of recall bias, likely jeopardizing the study result's credibility. Third, the use of secondary data may have limited the comprehensiveness of the study variables. For example, main variables like social anxiety were measured using specific questions from the original Social Anxiety Scale for Adolescents (SAS-A), and the usage of these selected yet readily available variables may unknowingly neglect other major aspects of social anxiety, namely the social avoidance and distress in general (SAD-G) domain. Fourth, just like any longitudinal study, lost to follow-up issue of study data source was also concerning. Approximately only 44% of the original sample of 2,855 participants were analyzable. Fifth, the association between social anxiety trajectories and social jetlag, specifically the “high stable” pattern, was only marginally significant. Future studies with larger sample size are recommended to confirm such association. Last, findings from this study do not imply direct causal relationships between social anxiety trajectories and social jetlag nor indirect causal relations caused by depressive symptoms. Further experimental research is necessary to determine causality. Taken together, caution should be exercised when generalizing and extrapolating study results to other populations.

Chapter 6 Conclusion and Implications



This chapter presents the study's conclusion by synthesizing the main findings associated with the study's research objectives. Implications were proposed as considerations for future scholars and policymakers when promoting sleep health among young adults.

6.1 Conclusion

6.1.1 Characteristics of social anxiety, social jetlag, and other variables

In sum, the mean social anxiety score of participants aged 7 to 20 was between 9.48 and 10.41. The proportion of participants with social jetlag, with a cut-off point of 1-hour, was 46.85%, while prior social jetlag was 46.13%. The mean score for mediating depressive symptoms (8.98) was slightly lower than prior depressive symptoms (9.29). The most frequently reported category for covariates like paternal and maternal education level, paternal and maternal income, and family structure was university and above, monthly income between NT\$40,000 and NT\$99,999, and two-parent families, respectively.

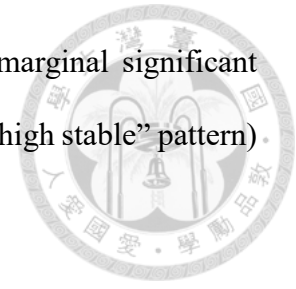
6.1.2 Social anxiety trajectories from middle childhood to young adulthood

The study sample demonstrated five groups of social anxiety trajectories, including: "low stable", "moderate increasing", "moderate to low", "high stable," and "high increasing". Each trajectory membership contained 49.16%, 21.23%, 16.92%, 7.34%, and 5.35% of the sample.

6.1.3 Associations between social anxiety trajectories and social jetlag

Multiple logistic regression revealed nonsignificant associations between three social anxiety trajectories (particularly the "moderate increasing", "moderate to

low”, and “high increasing” pattern) and social jetlag; and marginal significant association between social anxiety trajectory (specifically the “high stable” pattern) and social jetlag.

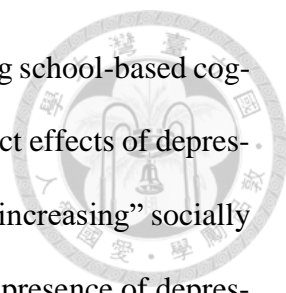


6.1.4 Mediating role of depressive symptoms between social anxiety trajectories and social jetlag

Mediation analyses found significant indirect effects of depressive symptoms on the relationship between “moderate increasing” social anxiety trajectory and social jetlag. Similar mediating effects were discovered between “moderate to low” and “high increasing” social anxiety trajectories and social jetlag. Specifically, compared to the “low stable” pattern, people with “moderate increasing” or “high increasing” social anxiety trajectories were likely to have higher depressive symptoms, leading to a higher probability of developing social jetlag. Conversely, individuals with “moderate to low” pattern social anxiety trajectories were likely to have lower levels of depressive symptoms, leading to a lower chance of developing social jetlag.

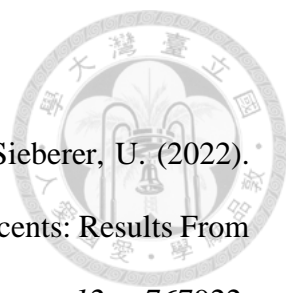
6.2 Implications

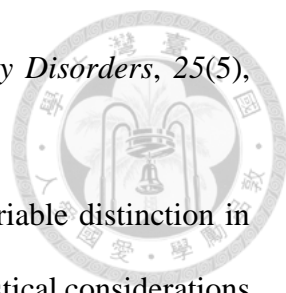
The findings contribute to a better understanding of the association between social anxiety trajectories and social jetlag among Taiwanese samples. The present research highlights the complex mediating role of depressive symptoms in their relationship. The current study emphasizes the need to notice the long-term effect of social anxiety from childhood to young adulthood. Despite marginal significance, it could provide practical implications for social jetlag preventative measures, especially among individuals with highly stable social anxiety trajectories. For instance, the author suggests promoting sleep health by

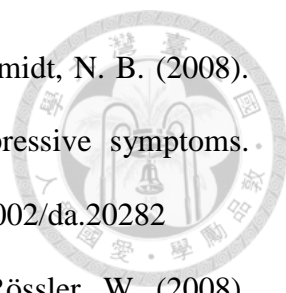


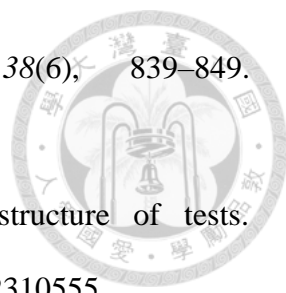
improving social skills, increasing emotional awareness, or developing school-based cognitive behavioral therapy programs. Also, study results showed indirect effects of depressive symptoms in “moderate increasing”, “moderate to low” or “high increasing” socially anxious individuals and their association with later social jetlag. The presence of depressive symptoms should be considered when designing sleep health promotion interventions for people with social anxiety. Future investigations are necessary to validate the conclusions drawn from this study. In terms of methodology, future research could consider including the social avoidance and distress in general (SAD-G) domain-related items excluded from this study’s data source. Comprehensive questionnaires measuring different dimensions of social anxiety could provide a more accurate picture of socially anxious individuals.

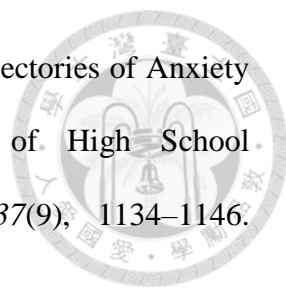
References


- 
- Adedeji, A., Otto, C., Kaman, A., Reiss, F., Devine, J., & Ravens-Sieberer, U. (2022). Peer Relationships and Depressive Symptoms Among Adolescents: Results From the German BELLA Study. *Frontiers in Psychology, 12*, 767922. <https://doi.org/10.3389/fpsyg.2021.767922>
- Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control, 19*(6), 716–723. <https://doi.org/10.1109/TAC.1974.1100705>
- Alfano, C. A., Ginsburg, G. S., & Kingery, J. N. (2007). Sleep-related problems among children and adolescents with anxiety disorders. *Journal of the American Academy of Child and Adolescent Psychiatry, 46*(2), 224–232. <https://doi.org/10.1097/01.chi.0000242233.06011.8e>
- American Psychiatric Association. (1987). *DSM-III-R*. American Psychiatric Association. <https://doi.org/10.1176/appi.books.9780890420188.dsm-iii-r>
- American Psychiatric Association (Ed.). (1994). *Diagnostic criteria from DSM-IV*. The Association.
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5TM, 5th ed* (pp. xliv, 947). American Psychiatric Publishing, Inc. <https://doi.org/10.1176/appi.books.9780890425596>
- Arain, M., Haque, M., Johal, L., Mathur, P., Nel, W., Rais, A., Sandhu, R., & Sharma, S. (2013). Maturation of the adolescent brain. *Neuropsychiatric Disease and Treatment, 9*, 449–461. <https://doi.org/10.2147/NDT.S39776>
- Babson, K., Feldner, M., Badour, C., Trainor, C., Blumenthal, H., Sachs-Ericsson, N., & Schmidt, N. (2011). Posttraumatic Stress and Sleep: Differential Relations across

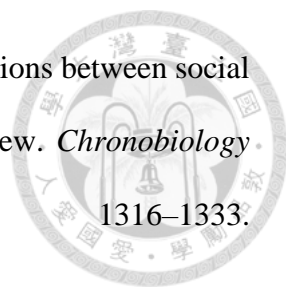
- 
- Types of Symptoms and Sleep Problems. *Journal of Anxiety Disorders*, 25(5), 706–713. <https://doi.org/10.1016/j.janxdis.2011.03.007>
- Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51, 1173–1182. <https://doi.org/10.1037/0022-3514.51.6.1173>
- Bodur, M., Baspinar, B., & Özçelik, A. Ö. (2021). A cross-sectional evaluation of the relationship between social jetlag and diet quality. *Chronobiology International*, 38(11), 1557–1568. <https://doi.org/10.1080/07420528.2021.1935990>
- Bögels, S., Stevens, J., & Majdandzić, M. (2010). Parenting and social anxiety: Fathers’ versus mothers’ influence on their children’s anxiety in ambiguous social situations. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 52, 599–606. <https://doi.org/10.1111/j.1469-7610.2010.02345.x>
- Bogusch, L. M., Fekete, E. M., & Skinta, M. D. (2016). Anxiety and Depressive Symptoms as Mediators of Trait Mindfulness and Sleep Quality in Emerging Adults. *Mindfulness*, 7(4), 962–970. <https://doi.org/10.1007/s12671-016-0535-7>
- Bonnet, M. H., & Arand, D. L. (2010). Hyperarousal and insomnia: State of the science. *Sleep Medicine Reviews*, 14(1), 9–15. <https://doi.org/10.1016/j.smr.2009.05.002>
- Broeren, S., Muris, P., Diamantopoulou, S., & Baker, J. (2012). The Course of Childhood Anxiety Symptoms: Developmental Trajectories and Child-Related Factors in Normal Children. *Journal of Abnormal Child Psychology*, 41. <https://doi.org/10.1007/s10802-012-9669-9>
- Brozovich, F., & Heimberg, R. G. (2008). An analysis of post-event processing in social anxiety disorder. *Clinical Psychology Review*, 28(6), 891–903. <https://doi.org/10.1016/j.cpr.2008.01.002>

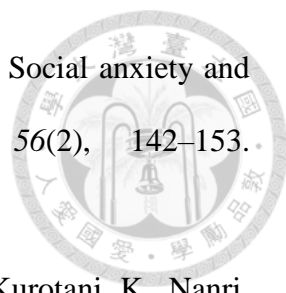
- 
- Buckner, J. D., Bernert, R. A., Cromer, K. R., Joiner, T. E., & Schmidt, N. B. (2008). Social anxiety and insomnia: The mediating role of depressive symptoms. *Depression and Anxiety, 25*(2), 124–130. <https://doi.org/10.1002/da.20282>
- Buysse, D. J., Angst, J., Gamma, A., Ajdacic, V., Eich, D., & Rössler, W. (2008). Prevalence, course, and comorbidity of insomnia and depression in young adults. *Sleep, 31*(4), 473–480. <https://doi.org/10.1093/sleep/31.4.473>
- Campbell, M. (1996). Does social anxiety increase with age? *Australian Journal of Guidance and Counselling, 6*. <https://doi.org/10.1017/S1037291100001485>
- Caplan, S. E. (2003). Preference for Online Social Interaction: A Theory of Problematic Internet Use and Psychosocial Well-Being. *Communication Research, 30*(6), 625–648. <https://doi.org/10.1177/0093650203257842>
- Carney, C. E., Edinger, J. D., Meyer, B., Lindman, L., & Istre, T. (2006). Symptom-Focused Rumination and Sleep Disturbance. *Behavioral Sleep Medicine, 4*(4), 228–241. https://doi.org/10.1207/s15402010bsm0404_3
- Chang, Y. H., Yen, L. L., Chang, H. Y., & Wu, W. C. (2010). A study of the developmental trajectory of social anxiety among boys and girls from 4th grade to 11th grade. *臺灣公共衛生雜誌, 29*(5), 465–476.
- Clancy, F., Prestwich, A., Caperon, L., & O'Connor, D. B. (2016). Perseverative Cognition and Health Behaviors: A Systematic Review and Meta-Analysis. *Frontiers in Human Neuroscience, 10*. <https://www.frontiersin.org/articles/10.3389/fnhum.2016.00534>
- Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. In *Social phobia: Diagnosis, assessment, and treatment* (pp. 69–93). The Guilford Press.
- Crocetti, E., Klimstra, T., Keijsers, L., Hale, W. W., & Meeus, W. (2009). Anxiety trajectories and identity development in adolescence: A five-wave longitudinal

- 
- study. *Journal of Youth and Adolescence*, 38(6), 839–849.
<https://doi.org/10.1007/s10964-008-9302-y>
- Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16(3), 297–334. <https://doi.org/10.1007/BF02310555>
- de la Torre-Luque, A., Fiol-Veny, A., Balle, M., Nelemans, S. A., & Bornas, X. (2020). Anxiety in Early Adolescence: Heterogeneous Developmental Trajectories, Associations with Risk Factors and Depressive Symptoms. *Child Psychiatry & Human Development*, 51(4), 527–541. <https://doi.org/10.1007/s10578-019-00936-y>
- de Matos, M. G., Barrett, P., Dadds, M., & Shortt, A. (2003). Anxiety, depression, and peer relationships during adolescence: Results from the Portuguese national health behaviour in school-aged children survey. *European Journal of Psychology of Education*, 18(1), 3–14. <https://doi.org/10.1007/BF03173600>
- Deboer, T. (2018). Sleep homeostasis and the circadian clock: Do the circadian pacemaker and the sleep homeostat influence each other's functioning? *Neurobiology of Sleep and Circadian Rhythms*, 5, 68–77. <https://doi.org/10.1016/j.nbscr.2018.02.003>
- Di, H., Guo, Y., Daghlas, I., Wang, L., Liu, G., Pan, A., Liu, L., & Shan, Z. (2022). Evaluation of Sleep Habits and Disturbances Among US Adults, 2017-2020. *JAMA Network Open*, 5(11), e2240788. <https://doi.org/10.1001/jamanetworkopen.2022.40788>
- Duchesne, S., Larose, S., Vitaro, F., & Tremblay, R. E. (2010). Trajectories of anxiety in a population sample of children: Clarifying the role of children's behavioral characteristics and maternal parenting. *Development and Psychopathology*, 22(2), 361–373. <https://doi.org/10.1017/S0954579410000118>

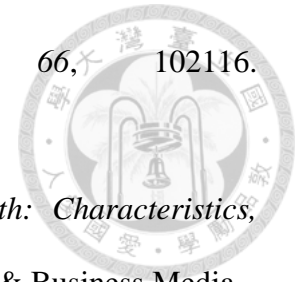
- 
- Duchesne, S., Vitaro, F., Larose, S., & Tremblay, R. E. (2008). Trajectories of Anxiety During Elementary-school Years and the Prediction of High School Noncompletion. *Journal of Youth and Adolescence*, 37(9), 1134–1146. <https://doi.org/10.1007/s10964-007-9224-0>
- Ehlers, C. L., Frank, E., & Kupfer, D. J. (1988). Social zeitgebers and biological rhythms. A unified approach to understanding the etiology of depression. *Archives of General Psychiatry*, 45(10), 948–952. <https://doi.org/10.1001/archpsyc.1988.01800340076012>
- Faulstich, M. E., Carey, M. P., Ruggiero, L., Enyart, P., & Gresham, F. (1986). Assessment of depression in childhood and adolescence: An evaluation of the Center for Epidemiological Studies Depression Scale for Children (CES-DC). *The American Journal of Psychiatry*, 143(8), 1024–1027. <https://doi.org/10.1176/ajp.143.8.1024>
- Feng, X., Shaw, D. S., & Silk, J. S. (2008). Developmental Trajectories of Anxiety Symptoms Among Boys Across Early and Middle Childhood. *Journal of Abnormal Psychology*, 117(1), 32. <https://doi.org/10.1037/0021-843X.117.1.32>
- Friedrich, M. J. (2017). Depression Is the Leading Cause of Disability Around the World. *JAMA*, 317(15), 1517. <https://doi.org/10.1001/jama.2017.3826>
- Fuller, K. H., Waters, W. F., Binks, P. G., & Anderson, T. (1997). Generalized Anxiety and Sleep Architecture: A Polysomnographic Investigation. *Sleep*, 20(5), 370–376. <https://doi.org/10.1093/sleep/20.5.370>
- Furmark, T., Tillfors, M., Everz, P., Marteinsdottir, I., Gefvert, O., & Fredrikson, M. (1999). Social phobia in the general population: Prevalence and sociodemographic profile. *Social Psychiatry and Psychiatric Epidemiology*, 34(8), 416–424. <https://doi.org/10.1007/s001270050163>

- 
- Gamboa Madeira, S., Reis, C., Paiva, T., Moreira, C. S., Nogueira, P., & Roenneberg, T. (2021). Social jetlag, a novel predictor for high cardiovascular risk in blue-collar workers following permanent atypical work schedules. *Journal of Sleep Research*, 30(6), e13380. <https://doi.org/10.1111/jsr.13380>
- Grant, B. F., Hasin, D. S., Blanco, C., Stinson, F. S., Chou, S. P., Goldstein, R. B., Dawson, D. A., Smith, S., Saha, T. D., & Huang, B. (2005). The epidemiology of social anxiety disorder in the United States: Results from the National Epidemiologic Survey on Alcohol and Related Conditions. *The Journal of Clinical Psychiatry*, 66(11), 1351–1361. <https://doi.org/10.4088/jcp.v66n1102>
- Guastella, A. J., & Moulds, M. L. (2007). The impact of rumination on sleep quality following a stressful life event. *Personality and Individual Differences*, 42(6), 1151–1162. <https://doi.org/10.1016/j.paid.2006.04.028>
- Harvey, A. G., & Greenall, E. (2003). Catastrophic worry in primary insomnia. *Journal of Behavior Therapy and Experimental Psychiatry*, 34(1), 11–23. [https://doi.org/10.1016/s0005-7916\(03\)00003-x](https://doi.org/10.1016/s0005-7916(03)00003-x)
- Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach* (pp. xvii, 507). Guilford Press.
- Haynie, D. L., Lewin, D., Luk, J. W., Lipsky, L. M., O'Brien, F., Iannotti, R. J., Liu, D., & Simons-Morton, B. G. (2018). Beyond Sleep Duration: Bidirectional Associations Among Chronotype, Social Jetlag, and Drinking Behaviors in a Longitudinal Sample of US High School Students. *Sleep*, 41(2), zsx202. <https://doi.org/10.1093/sleep/zsx202>
- Hena, M., & Garmy, P. (2020). Social Jetlag and Its Association With Screen Time and Nighttime Texting Among Adolescents in Sweden: A Cross-Sectional Study. *Frontiers in Neuroscience*, 14, 122. <https://doi.org/10.3389/fnins.2020.00122>

- 
- Henderson, S. E. M., Brady, E. M., & Robertson, N. (2019). Associations between social jetlag and mental health in young people: A systematic review. *Chronobiology International*, 36(10), 1316–1333. <https://doi.org/10.1080/07420528.2019.1636813>
- Hirsch, C. R., Meynen, T., & Clark, D. M. (2004). Negative self-imagery in social anxiety contaminates social interactions. *Memory (Hove, England)*, 12(4), 496–506. <https://doi.org/10.1080/09658210444000106>
- Hirshfeld-Becker, D. R., Biederman, J., Henin, A., Faraone, S. V., Davis, S., Harrington, K., & Rosenbaum, J. F. (2007). Behavioral inhibition in preschool children at risk is a specific predictor of middle childhood social anxiety: A five-year follow-up. *Journal of Developmental and Behavioral Pediatrics: JDBP*, 28(3), 225–233. <https://doi.org/10.1097/01.DBP.0000268559.34463.d0>
- Hitchcock, C. A., Chavira, D. A., & Stein, M. B. (2009). Recent Findings in Social Phobia among Children and Adolescents. *The Israel Journal of Psychiatry and Related Sciences*, 46(1), 34–44.
- Hofmann, S. G., Albano, A. M., Heimberg, R. G., Tracey, S., Chorpita, B. F., & Barlow, D. H. (1999). Subtypes of social phobia in adolescents. *Depression and Anxiety*, 9(1), 15–18.
- Holt, C. S., Heimberg, R. G., Hope, D. A., & Liebowitz, M. R. (1992). Situational domains of social phobia. *Journal of Anxiety Disorders*, 6(1), 63–77. [https://doi.org/10.1016/0887-6185\(92\)90027-5](https://doi.org/10.1016/0887-6185(92)90027-5)
- Horenstein, A., Morrison, A. S., Goldin, P., Ten Brink, M., Gross, J. J., & Heimberg, R. G. (2019). Sleep quality and treatment of social anxiety disorder. *Anxiety, Stress, and Coping*, 32(4), 387–398. <https://doi.org/10.1080/10615806.2019.1617854>

- 
- Hutchins, N., Allen, A., Curran, M., & Kannis-Dymand, L. (2021). Social anxiety and online social interaction. *Australian Psychologist*, 56(2), 142–153. <https://doi.org/10.1080/00050067.2021.1890977>
- Islam, Z., Hu, H., Akter, S., Kuwahara, K., Kochi, T., Eguchi, M., Kurotani, K., Nanri, A., Kabe, I., & Mizoue, T. (2020). Social jetlag is associated with an increased likelihood of having depressive symptoms among the Japanese working population: The Furukawa Nutrition and Health Study. *Sleep*, 43(1). <https://doi.org/10.1093/sleep/zsz204>
- Jefferies, P., & Ungar, M. (2020). Social anxiety in young people: A prevalence study in seven countries. *PLoS ONE*, 15(9), e0239133. <https://doi.org/10.1371/journal.pone.0239133>
- Jin, C. X., Sutherland, K., Gislason, T., Thorarinsdottir, E. H., Bittencourt, L., Tufik, S., Singh, B., McArdle, N., Cistulli, P., & Bin, Y. S. (2022). Influence of social jetlag on daytime sleepiness in obstructive sleep apnea. *Journal of Sleep Research*, e13772. <https://doi.org/10.1111/jsr.13772>
- Jones, B., Nagin, D., & Roeder, K. (2001). A SAS Procedure Based on Mixture Models for Estimating Developmental Trajectories. *Sociological Methods & Research*, 29. <https://doi.org/10.1177/0049124101029003005>
- Juda, M., Vetter, C., & Roenneberg, T. (2013). Chronotype modulates sleep duration, sleep quality, and social jet lag in shift-workers. *Journal of Biological Rhythms*, 28(2), 141–151. <https://doi.org/10.1177/0748730412475042>
- Kaplan, S. C., Butler, R. M., Devlin, E. A., Testa, R. J., Horenstein, A., Swee, M. B., & Heimberg, R. G. (2019). Rural living environment predicts social anxiety in transgender and gender nonconforming individuals across Canada and the United

States. *Journal of Anxiety Disorders*, 66, 102116.
<https://doi.org/10.1016/j.janxdis.2019.102116>



Kearney, C. (2006). *Social Anxiety and Social Phobia in Youth: Characteristics, Assessment, and Psychological Treatment*. Springer Science & Business Media.

Kennedy, S. H. (2008). Core symptoms of major depressive disorder: Relevance to diagnosis and treatment. *Dialogues in Clinical Neuroscience*, 10(3), 271–277.


Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry*, 62(6), 593–602. <https://doi.org/10.1001/archpsyc.62.6.593>

Kessler, R. C., Stein, M. B., & Berglund, P. (1998). Social phobia subtypes in the National Comorbidity Survey. *The American Journal of Psychiatry*, 155(5), 613–619. <https://doi.org/10.1176/ajp.155.5.613>

Kinge, J. M., Øverland, S., Flatø, M., Dieleman, J., Røgeberg, O., Magnus, M. C., Evensen, M., Tesli, M., Skrandal, A., Stoltenberg, C., Vollset, S. E., Håberg, S., & Torvik, F. A. (2021). Parental income and mental disorders in children and adolescents: Prospective register-based study. *International Journal of Epidemiology*, 50(5), 1615–1627. <https://doi.org/10.1093/ije/dyab066>

Koopman, A. D. M., Rauh, S. P., van 't Riet, E., Groeneveld, L., van der Heijden, A. A., Elders, P. J., Dekker, J. M., Nijpels, G., Beulens, J. W., & Rutters, F. (2017). The Association between Social Jetlag, the Metabolic Syndrome, and Type 2 Diabetes Mellitus in the General Population: The New Hoorn Study. *Journal of Biological Rhythms*, 32(4), 359–368. <https://doi.org/10.1177/07487304177113572>

Kreitzman, L., & Foster, R. (2011). *The Rhythms Of Life: The Biological Clocks That Control the Daily Lives of Every Living Thing*. Profile Books.

- 
- Krieg, A., & Xu, Y. (2015). Ethnic differences in social anxiety between individuals of Asian heritage and European heritage: A meta-analytic review. *Asian American Journal of Psychology*, 6, 66–80. <https://doi.org/10.1037/a0036993>
- La Greca, A. M., & Lopez, N. (1998). Social Anxiety Among Adolescents: Linkages with Peer Relations and Friendships. *Journal of Abnormal Child Psychology*, 26(2), 83–94. <https://doi.org/10.1023/A:1022684520514>
- Leary, M. R., & Kowalski, R. M. (1997). *Social Anxiety*. Guilford Press.
- Lecrubier, Y., & Weiller, E. (1997). Comorbidities in social phobia. *International Clinical Psychopharmacology*, 12 Suppl 6, S17-21. <https://doi.org/10.1097/00004850-199710006-00004>
- Leger, D., Richard, J.-B., Collin, O., Sauvet, F., & Faraut, B. (2020). Napping and weekend catchup sleep do not fully compensate for high rates of sleep debt and short sleep at a population level (in a representative nationwide sample of 12,637 adults). *Sleep Medicine*, 74, 278–288. <https://doi.org/10.1016/j.sleep.2020.05.030>
- Lépine, J. P., & Pélioso, A. (1996). Comorbidity and social phobia: Clinical and epidemiological issues. *International Clinical Psychopharmacology*, 11 Suppl 3, 35–41.
- Levandovski, R., Dantas, G., Fernandes, L. C., Caumo, W., Torres, I., Roenneberg, T., Hidalgo, M. P. L., & Allebrandt, K. V. (2011). Depression scores associate with chronotype and social jetlag in a rural population. *Chronobiology International*, 28(9), 771–778. <https://doi.org/10.3109/07420528.2011.602445>
- Levine, D. S., Taylor, R. J., Nguyen, A. W., Chatters, L. M., & Himle, J. A. (2015). Family and friendship informal support networks and social anxiety disorder among African Americans and Black Caribbeans. *Social Psychiatry and*

Psychiatric Epidemiology, 50(7), 1121–1133. <https://doi.org/10.1007/s00127-015-1023-4>

Li, X., Buxton, O. M., Kim, Y., Haneuse, S., & Kawachi, I. (2020). Do procrastinators get worse sleep? Cross-sectional study of US adolescents and young adults. *SSM - Population Health*, 10, 100518. <https://doi.org/10.1016/j.ssmph.2019.100518>

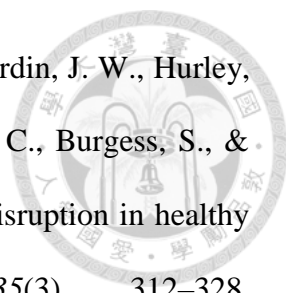
Lyneham, H., & Rapee, R. (2007). Childhood anxiety in rural and urban areas: Presentation, impact and help seeking. *Australian Journal of Psychology - AUST J PSYCHOL*, 59, 108–118. <https://doi.org/10.1080/00049530701317082>

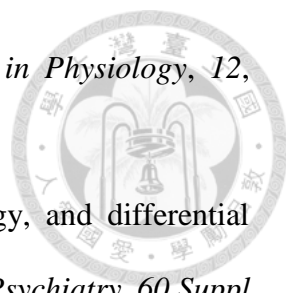
Marmorstein, N. R., White, H., Chung, T., Hipwell, A., Stouthamer-Loeber, M., & Loeber, R. (2010). Associations Between First Use of Substances and Change in Internalizing Symptoms Among Girls: Differences by Symptom Trajectory and Substance Use Type. *Journal of Clinical Child and Adolescent Psychology : The Official Journal for the Society of Clinical Child and Adolescent Psychology, American Psychological Association, Division 53*, 39(4), 545–558. <https://doi.org/10.1080/15374416.2010.486325>

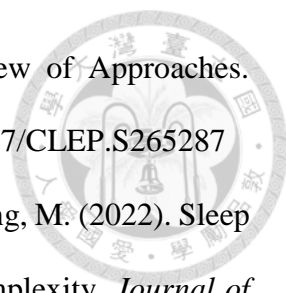
Martínez-Lozano, N., Barraco, G. M., Rios, R., Ruiz, M. J., Tvarijonaviciute, A., Fardy, P., Madrid, J. A., & Garaulet, M. (2020). Evening types have social jet lag and metabolic alterations in school-age children. *Scientific Reports*, 10(1), 16747. <https://doi.org/10.1038/s41598-020-73297-5>

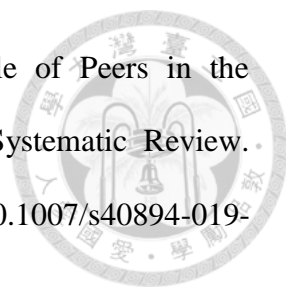
Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, 50, 370–396. <https://doi.org/10.1037/h0054346>

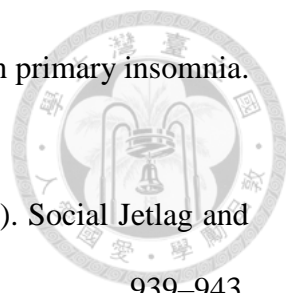
Mathew, G. M., Hale, L., & Chang, A.-M. (2020). Social Jetlag, Eating Behaviours, and Body Mass Index among Adolescents in the United States. *The British Journal of Nutrition*, 124(9), 979–987. <https://doi.org/10.1017/S0007114520001804>

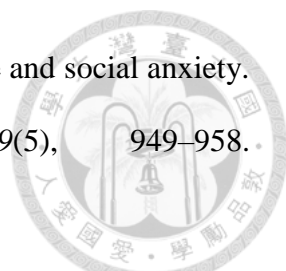
- 
- McMahon, D. M., Burch, J. B., Wirth, M. D., Youngstedt, S. D., Hardin, J. W., Hurley, T. G., Blair, S. N., Hand, G. A., Shook, R. P., Drenowatz, C., Burgess, S., & Hebert, J. R. (2018). Persistence of social jetlag and sleep disruption in healthy young adults. *Chronobiology International*, 35(3), 312–328. <https://doi.org/10.1080/07420528.2017.1405014>
- McMahon, D. M., Burch, J. B., Youngstedt, S. D., Wirth, M. D., Hardin, J. W., Hurley, T. G., Blair, S. N., Hand, G. A., Shook, R. P., Drenowatz, C., Burgess, S., & Hebert, J. R. (2019). Relationships between chronotype, social jetlag, sleep, obesity and blood pressure in healthy young adults. *Chronobiology International*, 36(4), 493–509. <https://doi.org/10.1080/07420528.2018.1563094>
- Meier, S. M., Mattheisen, M., Mors, O., Mortensen, P. B., Laursen, T. M., & Penninx, B. W. (2016). Increased mortality among people with anxiety disorders: Total population study. *The British Journal of Psychiatry: The Journal of Mental Science*, 209(3), 216–221. <https://doi.org/10.1192/bjp.bp.115.171975>
- Mellman, T. A. (2006). Sleep and Anxiety Disorders. *Psychiatric Clinics*, 29(4), 1047–1058. <https://doi.org/10.1016/j.psc.2006.08.005>
- Meredith, W., & Tisak, J. (1990). Latent curve analysis. *Psychometrika*, 55(1), 107–122. <https://doi.org/10.1007/BF02294746>
- Miers, A. C., Blöte, A. W., de Rooij, M., Bokhorst, C. L., & Westenberg, P. M. (2013). Trajectories of Social Anxiety during Adolescence and Relations with Cognition, Social Competence, and Temperament. *Journal of Abnormal Child Psychology*, 41(1), 97–110. <https://doi.org/10.1007/s10802-012-9651-6>
- Mota, M. C., Silva, C. M., Balieiro, L. C. T., Fahmy, W. M., Marqueze, E. C., Moreno, C. R. de C., & Crispim, C. A. (2021). Social Jetlag Is Associated With Impaired

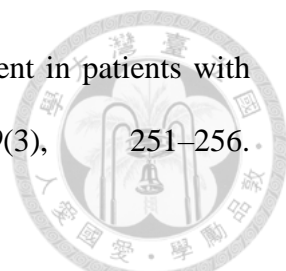
- 
- Metabolic Control During a 1-Year Follow-Up. *Frontiers in Physiology*, *12*, 702769. <https://doi.org/10.3389/fphys.2021.702769>
- Moutier, C. Y., & Stein, M. B. (1999). The history, epidemiology, and differential diagnosis of social anxiety disorder. *The Journal of Clinical Psychiatry*, *60 Suppl* 9, 4–8.
- Muthén, B., & Shedden, K. (1999). Finite mixture modeling with mixture outcomes using the EM algorithm. *Biometrics*, *55*(2), 463–469. <https://doi.org/10.1111/j.0006-341x.1999.00463.x>
- Nagin, D. S. (1999). Analyzing developmental trajectories: A semiparametric, group-based approach. *Psychological Methods*, *4*, 139–157. <https://doi.org/10.1037/1082-989X.4.2.139>
- Nagin, D. S., & Land, K. C. (1993). Age, Criminal Careers, and Population Heterogeneity: Specification and Estimation of a Nonparametric, Mixed Poisson Model*. *Criminology*, *31*(3), 327–362. <https://doi.org/10.1111/j.1745-9125.1993.tb01133.x>
- Nagin, D. S., & Odgers, C. L. (2010). Group-based trajectory modeling in clinical research. *Annual Review of Clinical Psychology*, *6*, 109–138. <https://doi.org/10.1146/annurev.clinpsy.121208.131413>
- Nandi, A., Beard, J. R., & Galea, S. (2009). Epidemiologic heterogeneity of common mood and anxiety disorders over the lifecourse in the general population: A systematic review. *BMC Psychiatry*, *9*(1), 31. <https://doi.org/10.1186/1471-244X-9-31>
- Nguefack, H. L., Pagé, M. G., Katz, J., Choinière, M., Vanasse, A., Dorais, M., Samb, O. M., & Lacasse, A. (2020). Trajectory Modelling Techniques Useful to


- 
- Epidemiological Research: A Comparative Narrative Review of Approaches. *Clinical Epidemiology*, 12, 1205–1222. <https://doi.org/10.2147/CLEP.S265287>
- Nilsen, S. A., Bergström, M., Sivertsen, B., Stormark, K. M., & Hysing, M. (2022). Sleep in adolescence: Considering family structure and family complexity. *Journal of Marriage and Family*, 84(4), 1152–1174. <https://doi.org/10.1111/jomf.12844>
- Norton, G. R., Cox, B. J., Hewitt, P. L., & McLeod, L. (1997). Personality factors associated with generalized and non-generalized social anxiety. *Personality and Individual Differences*, 22(5), 655–660. [https://doi.org/10.1016/S0191-8869\(96\)00243-7](https://doi.org/10.1016/S0191-8869(96)00243-7)
- Nowland, R., & Qualter, P. (2020). Influence of social anxiety and emotional self-efficacy on pre-transition concerns, social threat sensitivity, and social adaptation to secondary school. *The British Journal of Educational Psychology*, 90(1), 227–244. <https://doi.org/10.1111/bjep.12276>
- Nutt, D., Wilson, S., & Paterson, L. (2008). Sleep disorders as core symptoms of depression. *Dialogues in Clinical Neuroscience*, 10(3), 329–336.
- Ohayon, M. M., & Sagales, T. (2010). Prevalence of insomnia and sleep characteristics in the general population of Spain. *Sleep Medicine*, 11(10), 1010–1018. <https://doi.org/10.1016/j.sleep.2010.02.018>
- Oren-Yagoda, R., Melamud-Ganani, I., & Aderka, I. M. (2022). All by myself: Loneliness in social anxiety disorder. *Journal of Psychopathology and Clinical Science*, 131(1), 4–13. <https://doi.org/10.1037/abn0000705>
- Parsons, M. J., Moffitt, T. E., Gregory, A. M., Goldman-Mellor, S., Nolan, P. M., Poulton, R., & Caspi, A. (2015). Social jetlag, obesity and metabolic disorder: Investigation in a cohort study. *International Journal of Obesity* (2005), 39(5), 842–848. <https://doi.org/10.1038/ijo.2014.201>

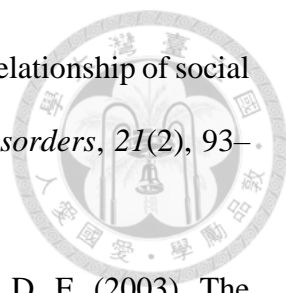
- 
- Pickering, L., Hadwin, J. A., & Kovshoff, H. (2020). The Role of Peers in the Development of Social Anxiety in Adolescent Girls: A Systematic Review. *Adolescent Research Review*, 5(4), 341–362. <https://doi.org/10.1007/s40894-019-00117-x>
- Pillai, V., & Drake, C. L. (2015). Chapter 10 - Sleep and Repetitive Thought: The Role of Rumination and Worry in Sleep Disturbance. In K. A. Babson & M. T. Feldner (Eds.), *Sleep and Affect* (pp. 201–225). Academic Press. <https://doi.org/10.1016/B978-0-12-417188-6.00010-4>
- Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments & Computers*, 36, 717–731. <https://doi.org/10.3758/BF03206553>
- Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, 40(3), 879–891. <https://doi.org/10.3758/BRM.40.3.879>
- Ram, N., & Grimm, K. J. (2009). Growth Mixture Modeling: A Method for Identifying Differences in Longitudinal Change Among Unobserved Groups. *International Journal of Behavioral Development*, 33(6), 565–576. <https://doi.org/10.1177/0165025409343765>
- Ramsawh, H. J., Stein, M. B., Belik, S.-L., Jacobi, F., & Sareen, J. (2009). Relationship of anxiety disorders, sleep quality, and functional impairment in a community sample. *Journal of Psychiatric Research*, 43(10), 926–933. <https://doi.org/10.1016/j.jpsychires.2009.01.009>
- Rapee, R. M., & Spence, S. H. (2004). The etiology of social phobia: Empirical evidence and an initial model. *Clinical Psychology Review*, 24(7), 737–767. <https://doi.org/10.1016/j.cpr.2004.06.004>

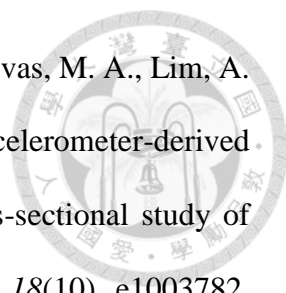
- 
- Rodenbeck, A., & Hajak, G. (2001). Neuroendocrine dysregulation in primary insomnia. *Revue Neurologique*, *157*(11 Pt 2), S57-61.
- Roenneberg, T., Allebrandt, K. V., Mellow, M., & Vetter, C. (2012). Social Jetlag and Obesity. *Current Biology*, *22*(10), 939–943.
<https://doi.org/10.1016/j.cub.2012.03.038>
- Roenneberg, T., Kuehnl, T., Pramstaller, P. P., Ricken, J., Havel, M., Guth, A., & Mellow, M. (2004). A marker for the end of adolescence. *Current Biology*, *14*(24), R1038–R1039. <https://doi.org/10.1016/j.cub.2004.11.039>
- Rusu, A., Ciobanu, D., Bala, C., Cerghizan, A., & Roman, G. (2019). Social jetlag, sleep-related parameters, and glycemic control in adults with type 1 diabetes: Results of a cross-sectional study. *Journal of Diabetes*, *11*(5), 394–401.
<https://doi.org/10.1111/1753-0407.12867>
- Rutters, F., Lemmens, S. G., Adam, T. C., Bremner, M. A., Elders, P. J., Nijpels, G., & Dekker, J. M. (2014). Is social jetlag associated with an adverse endocrine, behavioral, and cardiovascular risk profile? *Journal of Biological Rhythms*, *29*(5), 377–383. <https://doi.org/10.1177/0748730414550199>
- Schneier, F. R., Johnson, J., Hornig, C. D., Liebowitz, M. R., & Weissman, M. M. (1992). Social phobia. Comorbidity and morbidity in an epidemiologic sample. *Archives of General Psychiatry*, *49*(4), 282–288.
<https://doi.org/10.1001/archpsyc.1992.01820040034004>
- Schwarz, G. (1978). Estimating the Dimension of a Model. *The Annals of Statistics*, *6*(2).
<https://doi.org/10.1214/aos/1176344136>
- Shear, M. K., Randall, J., Monk, T. H., Ritenour, A., Tu, X., Frank, E., Reynolds, C., & Kupfer, D. J. (1994). Social rhythm in anxiety disorder patients. *Anxiety*, *1*(2), 90–95. <https://doi.org/10.1002/anxi.3070010208>

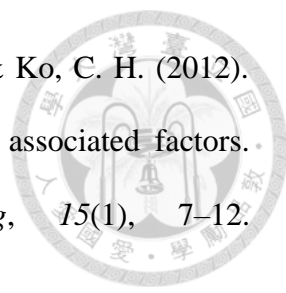
- 
- Shepherd, R.-M., & Edelmann, R. J. (2005). Reasons for internet use and social anxiety. *Personality and Individual Differences*, 39(5), 949–958. <https://doi.org/10.1016/j.paid.2005.04.001>
- Sobel, M. E. (1982). Asymptotic Confidence Intervals for Indirect Effects in Structural Equation Models. *Sociological Methodology*, 13, 290. <https://doi.org/10.2307/270723>
- Soehner, A. M., Kaplan, K. A., & Harvey, A. G. (2014). Prevalence and clinical correlates of co-occurring insomnia and hypersomnia symptoms in depression. *Journal of Affective Disorders*, 167, 93–97. <https://doi.org/10.1016/j.jad.2014.05.060>
- Spiegel, K., Leproult, R., & Van Cauter, E. (1999). Impact of sleep debt on metabolic and endocrine function. *Lancet (London, England)*, 354(9188), 1435–1439. [https://doi.org/10.1016/S0140-6736\(99\)01376-8](https://doi.org/10.1016/S0140-6736(99)01376-8)
- Staner, L. (2003). Sleep and anxiety disorders. *Dialogues in Clinical Neuroscience*, 5(3), 249–258.
- Stein, D. J., Lim, C. C. W., Roest, A. M., de Jonge, P., Aguilar-Gaxiola, S., Al-Hamzawi, A., Alonso, J., Benjet, C., Bromet, E. J., Bruffaerts, R., de Girolamo, G., Florescu, S., Gureje, O., Haro, J. M., Harris, M. G., He, Y., Hinkov, H., Horiguchi, I., Hu, C., ... Scott, K. M. (2017). The cross-national epidemiology of social anxiety disorder: Data from the World Mental Health Survey Initiative. *BMC Medicine*, 15, 143. <https://doi.org/10.1186/s12916-017-0889-2>
- Stein, M. B., Fuetsch, M., Müller, N., Höfler, M., Lieb, R., & Wittchen, H.-U. (2001). Social Anxiety Disorder and the Risk of Depression: A Prospective Community Study of Adolescents and Young Adults. *Archives of General Psychiatry*, 58(3), 251–256. <https://doi.org/10.1001/archpsyc.58.3.251>

- 
- Stein, M. B., Kroft, C. D., & Walker, J. R. (1993). Sleep impairment in patients with social phobia. *Psychiatry Research*, 49(3), 251–256. [https://doi.org/10.1016/0165-1781\(93\)90065-o](https://doi.org/10.1016/0165-1781(93)90065-o)
- Stein, M. B., & Stein, D. J. (2008). Social anxiety disorder. *Lancet (London, England)*, 371(9618), 1115–1125. [https://doi.org/10.1016/S0140-6736\(08\)60488-2](https://doi.org/10.1016/S0140-6736(08)60488-2)
- Stein, M. B., Tancer, M. E., Gelernter, C. S., Vittone, B. J., & Uhde, T. W. (1990). Major depression in patients with social phobia. *The American Journal of Psychiatry*, 147(5), 637–639. <https://doi.org/10.1176/ajp.147.5.637>
- Stoner, L., Castro, N., Signal, L., Skidmore, P., Faulkner, J., Lark, S., Williams, M. A., Muller, D., & Harrex, H. (2018). Sleep and Adiposity in Preadolescent Children: The Importance of Social Jetlag. *Childhood Obesity*, 14(3), 158–164. <https://doi.org/10.1089/chi.2017.0272>
- Südy, Á. R., Ella, K., Bódizs, R., & Káldi, K. (2019). Association of Social Jetlag With Sleep Quality and Autonomic Cardiac Control During Sleep in Young Healthy Men. *Frontiers in Neuroscience*, 0. <https://doi.org/10.3389/fnins.2019.00950>
- Teo, A. R., Lerrigo, R., & Rogers, M. A. M. (2013). The role of social isolation in social anxiety disorder: A systematic review and meta-analysis. *Journal of Anxiety Disorders*, 27(4), 353–364. <https://doi.org/10.1016/j.janxdis.2013.03.010>
- Torvik, F. A., Eilertsen, E. M., McAdams, T. A., Gustavson, K., Zachrisson, H. D., Brandlistuen, R., Gjerde, L. C., Havdahl, A., Stoltenberg, C., Ask, H., & Ystrom, E. (2020). Mechanisms linking parental educational attainment with child ADHD, depression, and academic problems: A study of extended families in The Norwegian Mother, Father and Child Cohort Study. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 61(9), 1009–1018. <https://doi.org/10.1111/jcpp.13197>

- 
- Tousignant, O. H., Taylor, N. D., Suvak, M. K., & Fireman, G. D. (2019). Effects of Rumination and Worry on Sleep. *Behavior Therapy*, 50(3), 558–570. <https://doi.org/10.1016/j.beth.2018.09.005>
- Troxel, W. M., Lee, L., Hall, M., & Matthews, K. A. (2014). Single-parent family structure and sleep problems in black and white adolescents. *Sleep Medicine*, 15(2), 255–261. <https://doi.org/10.1016/j.sleep.2013.10.012>
- Turner, E. L., Dobson, J. E., & Pocock, S. J. (2010). Categorisation of continuous risk factors in epidemiological publications: A survey of current practice. *Epidemiologic Perspectives & Innovations: EP+I*, 7, 9. <https://doi.org/10.1186/1742-5573-7-9>
- Turner, S. M., Beidel, D. C., Dancu, C. V., & Keys, D. J. (1986). Psychopathology of social phobia and comparison to avoidant personality disorder. *Journal of Abnormal Psychology*, 95(4), 389–394. <https://doi.org/10.1037//0021-843x.95.4.389>
- Turner, S. M., Beidel, D. C., & Townsley, R. M. (1992). Social phobia: A comparison of specific and generalized subtypes and avoidant personality disorder. *Journal of Abnormal Psychology*, 101(2), 326–331. <https://doi.org/10.1037//0021-843x.101.2.326>
- Väänänen, J.-M., Fröjd, S., Ranta, K., Marttunen, M., Helminen, M., & Kaltiala-Heino, R. (2011). Relationship between social phobia and depression differs between boys and girls in mid-adolescence. *Journal of Affective Disorders*, 133(1), 97–104. <https://doi.org/10.1016/j.jad.2011.03.036>
- Vadnie, C. A., & McClung, C. A. (2017). Circadian Rhythm Disturbances in Mood Disorders: Insights into the Role of the Suprachiasmatic Nucleus. *Neural Plasticity*, 2017, 1504507. <https://doi.org/10.1155/2017/1504507>

- 
- Van Ameringen, M., Mancini, C., Styan, G., & Donison, D. (1991). Relationship of social phobia with other psychiatric illness. *Journal of Affective Disorders*, 21(2), 93–99. [https://doi.org/10.1016/0165-0327\(91\)90055-W](https://doi.org/10.1016/0165-0327(91)90055-W)
- Van Dongen, H. P. A., Maislin, G., Mullington, J. M., & Dinges, D. F. (2003). The cumulative cost of additional wakefulness: Dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. *Sleep*, 26(2), 117–126. <https://doi.org/10.1093/sleep/26.2.117>
- Van Oort, F. V. A., Greaves-Lord, K., Verhulst, F. C., Ormel, J., & Huizink, A. C. (2009). The developmental course of anxiety symptoms during adolescence: The TRAILS study. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 50(10), 1209–1217. <https://doi.org/10.1111/j.1469-7610.2009.02092.x>
- Vassilopoulos, S. (2004). Anticipatory processing in social anxiety. *Behavioural and Cognitive Psychotherapy*, 32, 303–311. <https://doi.org/10.1017/S1352465804001377>
- Villarroel, M. A., & Terlizzi, E. P. (2020). Symptoms of Depression Among Adults: United States, 2019. *NCHS Data Brief*, 379, 1–8.
- Vreeburg, S. A., Hoogendijk, W. J. G., van Pelt, J., DeRijk, R. H., Verhagen, J. C. M., van Dyck, R., Smit, J. H., Zitman, F. G., & Penninx, B. W. J. H. (2009). Major Depressive Disorder and Hypothalamic-Pituitary-Adrenal Axis Activity: Results From a Large Cohort Study. *Archives of General Psychiatry*, 66(6), 617–626. <https://doi.org/10.1001/archgenpsychiatry.2009.50>
- Vriends, N., Becker, E. S., Meyer, A., Michael, T., & Margraf, J. (2007). Subtypes of social phobia: Are they of any use? *Journal of Anxiety Disorders*, 21(1), 59–75. <https://doi.org/10.1016/j.janxdis.2006.05.002>

- 
- Wainberg, M., Jones, S. E., Beaupre, L. M., Hill, S. L., Felsky, D., Rivas, M. A., Lim, A. S. P., Ollila, H. M., & Tripathy, S. J. (2021). Association of accelerometer-derived sleep measures with lifetime psychiatric diagnoses: A cross-sectional study of 89,205 participants from the UK Biobank. *PLOS Medicine*, *18*(10), e1003782. <https://doi.org/10.1371/journal.pmed.1003782>
- Wittchen, H. U., Stein, M. B., & Kessler, R. C. (1999). Social fears and social phobia in a community sample of adolescents and young adults: Prevalence, risk factors and co-morbidity. *Psychological Medicine*, *29*(2), 309–323. <https://doi.org/10.1017/s0033291798008174>
- Wittmann, M., Dinich, J., Merrow, M., & Roenneberg, T. (2006). Social jetlag: Misalignment of biological and social time. *Chronobiology International*, *23*(1–2), 497–509. <https://doi.org/10.1080/07420520500545979>
- Wong, N., Sarver, D. E., & Beidel, D. C. (2012). Quality of Life Impairments among Adults with Social Phobia: The Impact of Subtype. *Journal of Anxiety Disorders*, *26*(1), 50–57. <https://doi.org/10.1016/j.janxdis.2011.08.012>
- Wong, P. M., Hasler, B. P., Kamarck, T. W., Muldoon, M. F., & Manuck, S. B. (2015). Social Jetlag, Chronotype, and Cardiometabolic Risk. *The Journal of Clinical Endocrinology and Metabolism*, *100*(12), 4612–4620. <https://doi.org/10.1210/jc.2015-2923>
- Wong, Q., Gregory, B., & McLellan, L. F. (2016). A Review of Scales to Measure Social Anxiety Disorder in Clinical and Epidemiological Studies. *Current Psychiatry Reports*, *18*(4), 38. <https://doi.org/10.1007/s11920-016-0677-2>
- Woody, S. R., Miao, S., & Kellman-McFarlane, K. (2015). Cultural differences in social anxiety: A meta-analysis of Asian and European heritage samples. *Asian American Journal of Psychology*, *6*, 47–55. <https://doi.org/10.1037/a0036548>

- 
- Yen, J. Y., Yen, C. F., Chen, C. S., Wang, P. W., Chang, Y. H., & Ko, C. H. (2012). Social anxiety in online and real-life interaction and their associated factors. *Cyberpsychology, Behavior and Social Networking*, 15(1), 7–12. <https://doi.org/10.1089/cyber.2011.0015>
- Yen, L. L., Chen, L., Lee, S. H., Hsiao, C., & Pan, L. Y. (2002). Child and adolescent behaviour in long-term evolution (CABLE): A school-based health lifestyle study. *Promotion & Education, Suppl 1*, 33–40. <https://doi.org/10.1177/10253823020090010115>
- Zhou, J.-N., Riemersma, R. F., Unmehopa, U. A., Hoogendijk, W. J. G., van Heerikhuize, J. J., Hofman, M. A., & Swaab, D. F. (2001). Alterations in Arginine Vasopressin Neurons in the Suprachiasmatic Nucleus in Depression. *Archives of General Psychiatry*, 58(7), 655–662. <https://doi.org/10.1001/archpsyc.58.7.655>

Appendices



Appendix 1: Regulations for the usage of CABLE project data

國家衛生研究院兒童及青少年行為之長期發展研究（簡稱 CABLE）計畫資料使用辦法

92年10月8日訂定
98年5月8日第一次修訂
109年1月16日第二次修訂

為充分運用 CABLE (Child and Adolescent Behaviors in Long-term Evolution: A School-based Health lifestyle Study) 計畫資料，以最適切之方式分析並撰寫成論文於國內外學術期刊上發表，一方面接受同儕審查以提昇研究水準；一方面可與各界交流研究成果，特訂定以下辦法：

1. 每年資料於收集完畢十八個月後可釋出，以供其他有興趣之研究人員使用。但參與 CABLE 計畫之研究生，在計畫主持人許可情況下，可以提前使用。
2. 參與 CABLE 計畫之研究生在指導教授協助下，利用 CABLE 計畫資料撰寫學位論文者，應於畢業時繳交「碩博士論文大摘要」（格式請洽計畫人員）一份，及論文電子檔予計畫辦公室。畢業後一年內可以第一作者發表論文於有同儕審查之學術期刊上；於期限內未完成投稿者，其指導教授得以第一作者（研究生為第二作者）改寫後另行發表。
3. 其他非屬 CABLE 研究群之人員，必須檢附申請書（如附件）、次級資料分析計畫書（包括：摘要、研究目的、研究架構及研究方法），及其 IRB 審查通過之許可函，且需與至少一位研究團隊成員合作完成。經 CABLE 計畫主持人及共同主持人審核通過後，方得就相關資料檔進行分析。
4. 申請者從取得資料到撰稿完成並投出，以一年為限；逾時未完成前述步驟者，日後不得以取得之 CABLE 資料做任何型式之發表，其原申請之研究題目可開放給其他有興趣者經申請同意後撰寫。
5. 核發之 CABLE 資料檔，僅限於該次審核通過之主題及用途，不得自行釋出或做再次使用。論文完成後，必須自行將該資料銷毀，不得保留任何型式之備份。如有任何違反事項，CABLE 研究群將循法律途徑告發處理，且申請者日後不得再提出使用 CABLE 資料之申請。
6. 所有期刊論文需包含以下致謝文字：

The authors thank the Child and Adolescent Behaviors in Long-term Evolution project (計畫編號), funded by National Health Research Institutes, for providing data for this study.

本研究係利用國家衛生研究院所執行之「兒童及青少年行為之長期發展研究」（計畫編號）部份資料進行分析，謹此致謝。

7. 所有論文稿件，應於投稿同時送交一份供 CABLE 計畫辦公室存查，並有義務主動告知投稿進度與審查結果。論文刊登後，申請者需送交全文電子檔予 CABLE 計畫辦公室。

本人已詳細閱讀上述辦法，並同意接受相關規定。

申請人：雲惟恩 2022年11月15日（簽章、日期）

指導教授：張齡才 2022/11/16（簽章、日期）

Appendix 2: Institutional Review Board Approval Letter



國立臺灣大學
行為與社會科學研究倫理委員會

Research Ethics Committee
National Taiwan University
No. 1, Sec. 4, Roosevelt Rd., Taipei, Taiwan 10617, R.O.C
Phone: 3366-9956 Fax: 2362-9082

審查核可證明

核可日期：2022年11月9日

倫委會案號：202210HM004

核可證明有效期限：2022年11月9日起至2023年6月30日

計畫名稱：探討社交焦慮發展軌跡與社會性時差之關係：以網路成癮為中介變項

校/院/系/計畫主持人：國立臺灣大學/公共衛生學院/健康行為與社區科學研究所/雲惟恩 碩士生

計畫文件版本日期：【研究計畫書，2022年10月30日】、【資料蒐集表，2022年10月30日】

上述計畫業經2022年11月9日國立臺灣大學行為與社會科學研究倫理委員會同意，符合研究倫理規範。本委員會的運作符合本校行為與社會科學研究倫理準則與規範及政府相關法律規章。

本案需經研究經費補助單位核准同意後，該計畫始得執行。

計畫主持人最遲應於本核可證明到期前的6週，提出持續審查申請表，本案需經持續審查，方可繼續執行。在計畫執行期間，若有計畫變更或嚴重不良反應事件，計畫主持人須依國內及本校相關法令規定通報本委員會。

行為與社會科學研究倫理委員會主任委員 鄭麗珍

Ethical Review Approval
National Taiwan University

Date of approval: November 09, 2022

NTU-REC No.: 202210HM004

Validity of this approval: from November 09, 2022 to June 30, 2023

Title of protocol: Associations between trajectories of social anxiety and social jetlag: Internet addiction as a mediator

University/ College/ Department/ Principal Investigator : National Taiwan University / College of Public Health / Institute of Health Behaviors and Community Sciences/ Master Student WOON VE ERN

Version date of documents : 【Research Protocol, October 30, 2022】，【Data Collection Sheet, October 30, 2022】

The protocol has been approved by Research Ethics Committee of National Taiwan University and has been classified as expedited on November 09, 2022. The committee is organized under, and operates in accordance with, Social and Behavioral Research Ethical Principles and Regulations of National Taiwan University and governmental laws and regulations.

Approval by funding agency is mandatory before project implementation.

Continuing Review Application should be submitted to Research Ethics Committee no later than six weeks before current approval expired. The investigator is required to report protocol amendment and Serious Adverse Events in accordance with the National Taiwan University and governmental laws and regulations.

Chairperson Li-Chen Cheng
Research Ethics Committee



Table A1 Social anxiety

Items	No.	Year	Questions	Scoring	Factor
7	1	2001-2014	Do you fear meeting new friends in the past two weeks?	1 to 3	Social avoidance specific to new situations or unfamiliar peers
	2	2001-2014	Do you fear that others will ridicule you in the past two weeks?	1 to 3	Fear of negative evaluation
	3	2001-2014	Do you fear talking to people you do not know in the past two weeks?	1 to 3	Social avoidance specific to new situations or unfamiliar peers
	4	2001-2014	Do you fear that others will laugh at you in the past two weeks?	1 to 3	Fear of negative evaluation
	5	2001-2014	Do you fear that others will judge you in the past two weeks?	1 to 3	Fear of negative evaluation
	6	2001-2014	Do you fear that others will dislike you in the past two weeks?	1 to 3	Fear of negative evaluation
	7	2001-2014	Do you fear being in public, whether performing in front of others or answering people's questions?	1 to 3	Social avoidance specific to new situations or unfamiliar peers

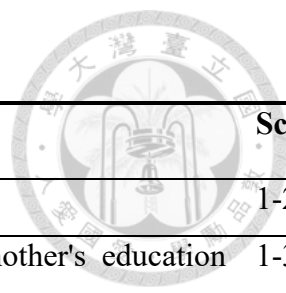


Table A2 Social jetlag

Items	No.	Years	Questions
8	1	2007-2014	Bedtime during school days or weekdays (hour)
	2	2007-2014	Bedtime during school days or weekdays (minute)
	3	2007-2014	Wake-up time during school days or weekdays (hour)
	4	2007-2014	Wake-up time during school days or weekdays (minute)
	5	2007-2014	Bedtime during free days or weekends (hour)
	6	2007-2014	Bedtime during free days or weekends (minute)
	7	2007-2014	Wake-up time during free days or weekends (hour)
	8	2007-2014	Wake-up time during free days or weekends (minute)

Table A3 Depressive symptoms

Items	No.	Year	Questions	Scoring
6	1	2001-2014	How often have you been bothered by poor appetite or overeating in the past two weeks?	1 to 3
	2	2001-2014	How often have you felt down or sad in the past two weeks?	1 to 3
	3	2001-2014	In the past two weeks, how often have you been crying without any reason?	1 to 3
	4	2001-2014	How often do you find it hard in the past two weeks when doing things?	1 to 3
	5	2001-2014	How often have you been feeling scared in the past two weeks?	1 to 3
	6	2001-2014	How often have you felt little interest or pleasure in doing things in the past two weeks?	1 to 3

Table A4 Covariates


Variable	Items	No.	Year	Questions	Scoring
Sex	1	1	2001	What is your sex?	1-2
Parental education	1	1	2004, 2007, 2010, 2011, 2013-2014	What is your father's or mother's education level?	1-3
Parental income	1	1	2001-2005	What is your average monthly income in the previous year (including salaries, agricultural income, business income, investment income, employee allowances, bonuses, and dividends)?	1-3
Family structure	1	1	2001-2006	What are your parents' marital status?	1-8 1-10 (2006)
		7	1	2007-2014	What are your parents' marital status?
		2	2007-2014	Do your parents live together? (deceased father)	0-1
		3	2007-2014	Do your parents live together? (deceased mother)	0-1
		4	2007-2014	Do your parents live together? (parents living together)	0-1
		5	2007-2014	Do your parents live together? (father come home only during the weekends)	0-1
		6	2007-2014	Do your parents live together? (mother come home only during the weekends)	0-1
		7	2007-2014	Do your parents live together? (parents do not live together)	0-1
Family support	7	1	2001-2014	Did your father or mother encourage you when you encountered problems or performed poorly in the past year?	1-4
		2	2001-2014	Did your father or mother praise you when you performed well in the past year?	1-4

3	2001-2014	Did your father or mother comfort you when you were feeling down in the past year?	1-4
---	-----------	--	-----

Table A4 Covariates (continued)

Variable	Items	No.	Year	Questions	Scoring
Family support	7	4	2001-2014	Did your father or mother care for you in the past year when you were not feeling well?	1-4
		5	2001-2014	Does your father or mother listen to you attentively when you have something to tell in the past year?	1-4
		6	2002-2014	Has your father or mother taken the initiative to care about you in the past year?	1-4
		7	2010-2014	Did your father or mother give you advice when you needed it in the past year?	1-4
Peer support	12	1	2007-2014	How do you get along with your close friends?: They listen to me when I am angry.	1-5
		2	2007-2014	They know much about me or care about me	1-5
		3	2007-2014	They comfort me when I am sad	1-5
		4	2007-2014	They are willing to spend time doing things with me	1-5
		5	2007-2014	They are willing to share their belongings with me	1-5
		6	2007-2014	They help me solve problems	1-5
		7	2007-2014	They give advice when I need to make a decision	1-5
		8	2007-2014	They remind or give advice to me from time to time	1-5
		9	2007-2014	They explain to me when I do not understand	1-5
		10	2007-2014	They talk about my strengths	1-5
		11	2007-2014	They compliment me when I perform well	1-5
		12	2007-2014	They ask for my advice when they need to make a decision	1-5

Table A5 Comparison between complete cases and original sample characteristics

	Complete cases (n=1,248)				Original sample (N=2,855)				Z/ χ^2
	n	%	Mean	SD	n	%	Mean	SD	
Sex									2.18
Male	605	48.48			1,455	50.98			
Female	643	51.52			1,399	49.02			
Paternal education level									0.54
Junior high school or below	102	8.17			228	8.03			
High school	402	32.21			884	31.15			
University or above	744	59.62			1,726	60.82			
Maternal education level									0.46
Junior high school or below	94	7.53			207	7.30			
High school	498	39.90			1,106	39.00			
University or above	656	52.56			1,523	53.70			
Paternal income									12.91**
≤NT\$39,999	165	13.22			450	15.76			
NT\$40,000 to NT\$99,999	670	53.69			1,362	47.71			
≥NT\$100,000	413	33.09			1,043	36.53			
Maternal income									7.37*
≤NT\$39,999	144	11.54			377	13.20			
NT\$40,000 to NT\$99,999	665	53.29			1,392	48.76			
≥NT\$100,000	439	35.18			1,086	38.04			
Family structure									2.34
Single-parent household	313	25.08			626	22.86			
Dual-parents household	935	74.92			2,112	77.14			
Social jetlag									258.97***
<1-hour	663	53.13			2,228	78.04			
≥1-hour	585	46.88			627	21.96			
Prior social jetlag									1.54
<1-hour	672	53.85			1,597	55.94			
≥1-hour	576	46.15			1,258	44.06			
Family support	1,248		17.30	3.19	2,853		17.21	3.36	0.31
Peer support	1,248		44.30	7.98	2,688		44.00	8.45	0.31
Prior depressive symptoms	1,248		9.29	1.56	2,853		9.15	1.59	7.71**

Notes. SD=standard deviation; Z= Mann-Whitney U test; χ^2 = Chi-squared test.

*p<0.05; ** p<0.01; ***p<0.001.

Table A5 Comparison between study sample and original sample characteristics (continued)

	Complete cases (n=1,248)				Original sample (N=2,855)				Z
	n	%	Mean	SD	n	%	Mean	SD	
Depressive symptoms	1,248		8.98	2.60	1,910		8.91	2.58	0.83
Social anxiety									
Age 7	995		10.11		2,199		10.11	3.07	0.09
Age 8	1,193		10.08		2,717		10.05	2.79	0.51
Age 9	1,143		9.81		2,572		9.81	2.71	0.50
Age 10	1,105		9.83		2,459		9.87	2.97	0.01
Age 11	1,087		9.63		2,394		9.61	2.82	0.33
Age 12	1,091		9.95		2,375		9.81	2.84	1.53
Age 13	1,086		10.06		2,314		9.91	3.00	1.60
Age 14	1,115		9.96		2,317		9.79	2.99	4.23*
Age 15	1,080		10.08		2,234		9.95	3.12	2.69
Age 16	1,168		10.42		2,282		10.28	3.28	1.74
Age 17	1,231		10.27		2,413		10.17	3.29	1.41
Age 18	1,193		9.92		2,214		9.84	3.19	0.25
Age 19	1,175		9.81		2,007		9.73	3.17	0.51
Age 20	1,168		9.49		1,915		9.37	3.05	1.15

Notes. SD=standard deviation; Z= Mann-Whitney U test.

*p<0.05.