A MIXED METHODS STUDY TO EXPLORE THE IMPACTS OF SCREENS AND SOCIAL MEDIA USE ON MENTAL HEALTH, SLEEP, AND PHYSICAL ACTIVITY AMONG ADOLESCENTS IN CHINA

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Abstract

Generation Z adolescents grow up in a social media environment. Some studies based in Western countries and high-income countries have shown social media use is associated with several health-related outcomes. This study focuses on Chinese adolescents, given the unique social media context of China, and explores the association between screen time, mobile phone and social media use, and a series of health-related outcomes (mental wellbeing, sleep, and physical activity).

The study is a mixed methods design. The quantitative study involved 4791 Chinese adolescents (ages 12–15, years 2020-2021) in a cross-sectional survey. The qualitative study involved 48 adolescents (ages 12-15, years 2020-2021) who participated in 8 focus groups. Findings from the two studies were integrated through the explanatory design.

The results of the quantitative study indicated that moderate social media (less than 2 hours) use may have beneficial associations with health outcomes such as higher mental wellbeing, and lower depression, and higher intensity activity in leisure time. Greater than two hours of social media use had detrimental associations with a wide range of health problems, such as poorer sleep quality, higher levels of anxiety, less numbers of days adolescents are physically active for at least 60 minutes, and less sleep duration. The findings of the qualitative study centred on three main themes of interaction, accessibility, and supervision in relation to social media use and physical activity: adolescents communicated with peers, celebrities, internet celebrities, and

friends about physical activity on social media; it provided a range of opportunities and resources for learning about physical activity; and social media also acted as a supervisory tool for adolescents' physical activity. The mixed methods study, through integration of the findings relating to the associations between social media use and physical activity and the qualitative findings relating to the content and types of physical activities accessed through social media, brings a more comprehensive understanding of how social media affects adolescents' physical activity.

This study provides a better understanding of the uses of social media in relation to mental health/wellbeing, sleep, and physical activity among Chinese adolescents, mitigating the research gap left by previous studies conducted in Western countries and high-income countries. The findings of the mixed methods study will help to inform future public health approaches to encouraging physical activity in this age group using social media as a tool. This may also have wider relevance to public health approaches which aim to promote adolescents' development and health.

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CHAPTER 1 INTRODUCTION

1.1 Screen time, electronic devices and social media among adolescents

Adolescents born in the late 1990s and early 2000s are perceived as being familiar with the use of digital technologies from a young age, and are often referred to as Generation Z (Turner, 2015). Since the 1990s, the Internet has replaced television as the main source of screen time in the lives of adolescents (PrakashYadav and Rai, 2017; Turner, 2015; Wood, 2013). Many adolescents use the Internet to engage with social media, such as, TikTok, YouTube, Snapchat, and Instagram (Ofcom UK, 2023; Vogels et al., 2022). It has been estimated that 87% of 12-15 year olds in the UK and about 90% of 3-17 year olds in the US are social media users (AACAP US, 2018; Ofcom, 2020). Adolescents' uses of social media has increased over time, with previous evidence from six European countries (Greece, Spain, Poland, the Netherlands, Romania, and Iceland) in 2014, reporting that 69.5% of European adolescents aged 14 to 17 used social media (Tsitsika et al., 2014). Overall, it can be summarised that approximately one in three users of the Internet and/or social media worldwide is under the age of 18 (Keeley and Little, 2017).

Adolescents tend to access the Internet and social media using mobile devices, such as smartphones or tablets (Anderson and Jiang, 2018b; Ofcom.UK, 2022), and these devices tend to be available in most family homes (Lauricella et al., 2015). A meta-analysis of 46 studies from Asia, Europe, North America, Australia, the Middle East and multiple countries, estimated that in 2019 adolescents' screen time was 4 hours per day, and that this had increased from 2.7 hours per day prior to 2019 (Madigan et

al., 2022). Adolescents owning a smartphone are likely to have higher screen time compared to adolescents who own a conventional mobile phone, because they have constant access to online content and social media (Lemola et al., 2015).

1.2 Definition of social media

In the early 2000s, the initial forms of social media emerged. Social media platforms during the early period, included Orkut and My Space, and these have now been superseded by newer sites and networks, such as Snapchat, Instagram and YouTube, and in China, WeChat, QQ, TikTok, and Weibo. Facebook was one of the main initial social media sites. Presently, Facebook use is still prevalent, but the design and features of Facebook have changed significantly since it was created in 2004. For example, Facebook was previously centred around a user profile and text-based interactions with a user's 'friends', however Facebook has evolved to become an interactive online space that hosts a range of activities, including: interactions through videos and images in the form of stories and reels; the advertisement of services or businesses through pages; private and/or group based 'chats' using messenger, groups and pages; entertainment through games; and shopping through Facebook marketplace. As a result of the vast ways in which social media has changed since the early 1990s, definitions of social media are wide-ranging and changeable (Miller et al., 2016).

The development of "social media" did not happen overnight. Earlier media that supported user interactions and the sharing of user-generated content also included

Blogger and LiveJournal, founded in 1999, and the online diary community, Open Diary, founded in 1998. In 2000, Jimmy Wales and Larry Sanger founded Wikipedia, the world's first open-source, online, collaborative encyclopaedia. In 2003, MySpace, aimed at teenagers and young adults, was founded, followed by Facebook in 2004, YouTube in 2005 and Twitter in 2006. The current social media landscape has expanded further. With the launch of Douyin[1] (or TikTok) in 2016, alongside other media such as Snapchat and Instagram, the functionality of social media has developed and largely centres around the use of visual and image- or video-based user-generated content.

As Kaplan and Haenlein (2010) (p.61) stated: 'social media is a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user generated content'. There are different types of social media, for example, social networking sites (e.g. Facebook), wikis (e.g. wikispaces), media sharing services (e.g. YouTube, TikTok, Instagram), blogging sites (e.g. Blogger or wordpress), micro-blogging services (e.g. Twitter), social bookmarking (e.g. Pinterest), bibliographic management tools (e.g. Zotero), presentation sharing tools (e.g. Slideshare), and multi-media messenger (Snapchat, Facebook Messenger) (Faizi et al., 2013; Manca and Ranieri, 2016). Notably, with the continuous development of social media, the forms and functions of social media are constantly changing. As a result the definitions also need to be updated (Miller et al., 2016). Gradually, the definition of social media has shifted emphasis from the different

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[1] Douyin and TikTok are two similar social video apps for smartphones, both founded and operated by China's ByteDance. Douyin users can record videos from 15 seconds to 1 minute, 3 minutes or up to 10 minutes, and upload videos, photos, etc. TikTok is the overseas version of Douyin.

platforms or the Internet to the content and type of interaction. Danah boyd, a pioneer of research regarding teenagers and social media, defined social media as the sites or services that were initiated in the early 2000s, which allow users to create and share their own content on social networks sites, video sharing sites, blogging and microblogging platforms and related tools (boyd, 2014). Moreover, interaction is a feature of social media, which offers one-to-one, many-to-many, many-to-one, asynchronous, synchronous, direct and indirect forms of interaction (Dron and Anderson, 2014; Jensen and Helles, 2017). Summarising this evidence, social media in this study refers to media that support users to consume and produce content, where users create their own profile and/or pages and receive, search, and interact with information.

1.3 Traditional and social media

In contemporary society, there are two distinguishable forms of communication, namely traditional media and social media, each of which exhibits unique characteristics and influences on society. Traditional media refers to established modes of mass communication, such as television, newspapers, and radio, that typically feature a hierarchical structure whereby professional journalists, editors, and producers control the dissemination of content (Logan, 2010; Peterson, 2003). Such media channels generally adhere to a one-to-many communication model whereby a singular message is broadcast to a wide audience (Becker and Wehner, 2001; Peterson, 2003). Conversely, social media is a more contemporary mode of communication that relies on digital technologies and the Internet (Turner, 2022). Social media platforms are more democratic in nature, allowing anyone to create and distribute content to a potentially large audience (Lovett and Staelin, 2016). The many-

to-many communication model is typically adopted by social media, thereby enabling multiple individuals to communicate simultaneously with numerous others (boyd and Ellison, 2007; Obar and Wildman, 2015). On the other hand, social media contains some affordances that also make it unique. boyd (2010) argues in her work on social network sites, that social media are a form of networked publics, that are shaped by four central affordances: persistence (online expressions and content can be kept for a long time), visibility (the public or potential audience can see), spreadability (the extent to which content can be shared and disseminated), and searchability (the content is easy to find).

1.4 Screen, electronic devices and social media use
1.4.1 Use of social media in the international community

In 2015, the Pew Research Centre, through systematic tracking, showed that 65% of US adults use social media. This figure was 7% in 2005, which means nearly a tenfold change in social media use from 2005-2015 (Perrin, 2015). In 2019, there were approximately 70% American adults using social media (Auxier and Anderson, 2021). High levels of use are also seen other countries. In a 2022 survey of 3651 UK adults, 87% of participants aged 16 to 24 years used social media, compared to 83% of 25-34 year olds and 74% of 35-44 year olds (Ofcom UK, 2023). In 2021, a communications and media survey of 12,046 Australians revealed that approximately 85% of participants aged 18-34 years reported using at least one social media platform in the past 6 months, while only 67% of participants who were over 35 years reported social media use (ACMA AU, 2021). According to the latest survey by the Pew Research Centre in 2021, YouTube and Reddit have emerged as the most favoured social media platforms among Americans (Auxier and Anderson, 2021). Notably,

YouTube has secured the top position as the most frequently used online platform, and its popularity continues to grow. TikTok, a latecomer, was used by about 21% of Americans, but it was more likely to be used by people under the age of 30 (Auxier and Anderson, 2021). Although Facebook remains one of the most extensively employed social platforms among US adults, its growth has stagnated over the past five years, alongside other platforms, including Instagram, Pinterest, LinkedIn, Snapchat, Twitter (now X), and WhatsApp (Auxier and Anderson, 2021). In the UK, YouTube, WhatsApp, Facebook and Instagram are the most popular social media platforms, while TikTok is gaining momentum with 85% of UK 16-24 year olds using TikTok (Ofcom UK, 2023). Facebook, YouTube and Instagram are the top three most popular social networking sites among Australian adults, with usage rates of 91%, 83% and 81% respectively. The usage rate of TikTok in this population is 26% (ACMA AU, 2021).

1.4.2   Social media in China

Many commercial social media sites, such as YouTube, Snapchat, Facebook, are accessed by people from different international contexts. However, China presents a unique context in that social media has developed in isolation from the rest of the world and at a very fast pace (Wang, 2016). In terms of the barriers of the Internet, the Chinese government has built a "Fang Huo Qiang" (Internet censorship) (Chiu et al., 2012), which results in difficulties for Chinese citizens who attempt to access apps and websites that are not owned by Chinese corporations. Restrictions on foreign websites and social media led China to create a bespoke social media environment for Chinese citizens, which in turn has caused a self-developed social media ecosystem to flourish. In 2022, there were around 1.02 billion social media users (around 76%) in China,

compared to 302.25 million users (around 90%) in the United States (Statista, 2022a). Facebook, YouTube, and Twitter are blocked in China. However, Tencent, WeChat and Weibo are Chinese-based social media platforms and have been attracting millions of users. As a result of the booming development of domestic social media platforms, China has become the world's biggest social media market (Statista, 2019).

A recent report by the China Internet Network Information Centre (CNNIC) evidenced that in June 2022, the number of instant messaging (refers to a class of applications represented by WeChat and QQ) users was 1.027 billion (CNNIC, 2022a). Short videos have also begun to sweep Chinese's social media use, and as of December 2022, China's short video apps, for example, Kuaishou[2] and Douyin, have exceeded one billion users (CNNIC, 2023). Online live broadcasts were engaged with by 716 million users (68.1% of the total Internet users) (CNNIC, 2022a). An earlier report (CNNIC, 2017), showed that mobile instant messaging tools are the main form of daily communication of social media users in China. QQ and WeChat were the two main integrated applications used for social information sharing on the Chinese Internet (CNNIC, 2017).

1.4.3   Adolescents' engagement with social media

According to a survey from the Pew Research Centre in 2015 (Lenhart et al., 2015), over 75% of US adolescents aged 13–17 years old reported using social media and

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[2] Kuaishou is a short video mobile application developed by Beijing Racer Technology Co. Formerly an app for creating and sharing GIF images, it was launched in 2011, and transformed into a short video community in 2012, with its main competitors being Douyin in China.

over 70% of these adolescents claimed that they had more than one social media account. In the 2015 Pew Research Centre's "U.S. Teen Social Media Use Survey" report, Facebook was main social media site used among adolescents, dominating the social lives of American adolescents at the time (Lenhart et al., 2015). However, the landscape of social media use has changed, and adolescents are often at the forefront of this change. According to the report centred on adolescents from Pew Research Centre in 2022, 95% of adolescents aged 13–17 years reported using social media in 2022 (Vogels et al., 2022). YouTube was most preferred by adolescents, and was used by 95% of adolescents, followed by TikTok (67%), Instagram and Snapchat (used by 60%). The proportion of teenage users of Facebook has declined (Vogels et al., 2022). Furthermore, the Pew Research Centre reported that the vast majority of teens have access to digital devices, such as smartphones (95%) (Vogels et al., 2022).

In China, around 90 percent of those aged up to 18 years access the Internet and have their own social media account (CNNIC, 2017). Nearly half access information on socially significant events through short videos and video platforms such as Douyin, KuaiShou and Bilibi[3]. There is also a significant difference in the ownership of Internet access devices in those under 18 years in urban and rural areas. The proportion of rural Internet users aged 6-18 years who own their own mobile phones is 69.2%, which is 10.9 percentage points higher than that of urban Internet users of the same age (58.3%) (CNNIC, 2022b). According to the Chinese National study on Internet use by those under 18 years in 2021 (including 26349 questionnaires for children, 13283

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[3] Bilibili was a video website for ACG (animation, comics, games) content creation and sharing in its early days, the headquarters is located in Shanghai, China. After more than ten years of development, it has developed a video website containing high-quality content that has been built by users and creators.

questionnaires for parents, and 1632 questionnaires for teachers), the proportion of high school students (age 16-18 years) who regularly use social media was 58.4%, for middle school students (age 12-16 years) the proportion was 51%, and for primary school students (age 6-12 years) it was 17.9% (CNNIC, 2022b; CNNIC, 2021). Furthermore, more than 60% of adolescents who were social media users said they used more than one social media site (Youth cn, 2015).

Similar to the United States, the emergence of short video applications has increased in China. A survey by the China Youth & Children Research Centre of 10095 students from the fourth grade of primary school (age 9-10 years) to the second grade of high school (age 17-18 years), reported nearly 70% of youth have used short videos (short video apps represented by Douyin and Kuaishou). The proportion of short videos used among Junior high school students (age 12-15 years) was higher than that of elementary school students (age 6-12 years) and high school students (age 15-18 years) (China Youth & Children Research Centre, 2022). Data from the *Youth Blue Book - Report on Internet Usage and Reading Practices of Chinese Minors* survey, involving 100 primary (age 6-12 years) and secondary (age 12-18 years) schools and off-campus education places in China, showed QQ (59.7%) and WeChat (30.4%) have high usage rates among children and adolescents (age 6-18 years) and have become the main social media platforms for this age group in China. On the other hand, this survey also showed that online chat was still an important form of communication among children and adolescents on the social media (Ji et al., 2018).

1.4.3.1 Social development in adolescence and the role of social media

Adolescence is a time of increasing independence and autonomy and many adolescents use social media in a way that their parents do not control (Nikken et al., 2014). During early (age 10-13 years) and middle adolescence (age 14-17 years), adolescents begin to develop their media habits, and start to explore traditional and social media (Len-Ríos et al., 2016). Moreover, during this time social media plays an important role in the social lives of young adolescents, helping them to keep in touch with friends and family, make new friends and communicate ideas (Allen et al., 2014; Uhls et al., 2017). In turn, interactions through social media support the development of perspectives on self, community and the world (boyd, 2007; O'Keeffe et al., 2011). Adolescents aged 12-15 years are becoming more socially independent; they are beginning to develop their own personalities through, for example, choosing their interests and hobbies and picking their preferred friendship groups (CDC.US, 2021). At the same time, they value their interactions with others on social media and enjoy creating and sharing content on it (Ofcom.UK, 2023). Social media can also support key events in the lives of adolescents, such as transitions between different schools. For example, in China, adolescents move from primary to secondary education at the age of 12 years. Within the new setting of secondary schools, adolescents can use social media to meet new friends (Hinduja and Patchin, 2008; Peter et al., 2005). At this point in the life course, relationships with friends are significant (Crockett et al., 1984; Kroger, 2000) and adolescents' exploration of self is developing (Pfeifer and Berkman, 2018). Thus, social media may play an important role in adolescents' heightened needs for identity exploration, self-expression, friendship, and peer acceptance during this particular developmental period (Gerwin et al., 2018).

1.5 Social media use and health-related outcomes

The dominant narratives that surround adolescents and social media use tend to be negative and focus on the potential for social media to have negative impacts on adolescent health and wellbeing. Negative impacts of social media use include, but are not limited to, heightened levels of depression and anxiety, worsened sleep problems, poor capacity to focus, poor academic performance and increased cybercrime (Alonzo et al., 2021; Lund et al., 2021; Sampasa-Kanyinga et al., 2019). Equally, however, emerging research suggests the potential for social media to have positive impacts on adolescents' health and wellbeing. Early learning, exposure to new ideas and knowledge, increased opportunities for social contact and support, and new opportunities to access health promotion information and messages are identified as benefits of using social media (Moreno et al., 2018; Parker et al., 2021; Villiard and Moreno, 2012). In the following sections, I will explore and summarise the current evidence about social media use and adolescents' health and wellbeing, and highlight the potential gaps in the current research.

1.5.1   Relationship between screen and social media use and mental health: quantitative evidence

Mental ill-health during adolescence is a major public health concern and results in substantial societal and economic burdens globally (Health, 2015; Patton and Borschmann, 2017). Adolescence is a vulnerable period for the development of depression and anxiety (McLaughlin and King, 2015). A nationally representative survey conducted in the US from 1991 to 2016, targeting 13–18-year-olds (n=1.1 million), showed that psychological wellbeing and mental health suddenly decreased

after 2012 (Twenge et al., 2018b). Spending more time on electronic communication and screens (e.g., social media, the Internet, texting, gaming) was considered to negatively influence mental health outcomes, and screen-based device use and social media use had become more common over time in adolescents, corresponding with the decline seen in mental health (Twenge et al., 2018b).

Regarding screen use overall and its association with mental health, a systematic review led by Hoare et al. (2016) (consisting of 32 studies on youth aged 10 to 24 years, including 24 cross-sectional studies, 6 longitudinal studies and 1 intervention study), found consistent associations between both psychological symptomatology and other mental health problems, and time spent utilising screens. Lower emotional wellbeing status was reported among young people utilising screens for more than 2–3 hours every day, compared with those using screens for less than two hours per day.

A systematic review of reviews (containing 13 reviews; 1 high quality, 9 medium, and 3 low quality) examined the effects of screen time on the health and wellbeing of children and adolescents (age 0-18 years) (Stiglic and Viner, 2019). This review showed moderately strong evidence for associations between screen time and higher depressive symptoms, moderate evidence for an association between screen time and poorer quality of life, and weak evidence for associations of screen time with anxiety (Stiglic and Viner, 2019). This review of reviews also reported weak evidence that small amounts (less than 2 hours per day) of daily screen use may have some benefits, it may indicate that the association between screen time and mental health is curvilinear. Non-linear relationships were also found in a large-scale survey of 120115

British adolescents aged 15 years by Przybylski and Weinstein (2017a), where moderate screen time (up to 2 hours) was not associated with harm to mental wellbeing. However, the harmful effects to mental wellbeing were reported at 2-3 hours of screen time on weekdays, and 4 hours on weekends (Przybylski and Weinstein, 2017a). In a review by Suchert et al. (2015) which included 91 studies (73 cross-sectional studies) that explored sedentary behaviours and mental health in children and adolescents (age 5-18 years), authors reported that the relationship between screen time and depressive symptoms in some studies followed a U-shaped trend, namely adolescents reporting a moderate intensity of time engaging in screen activities had the lowest scores of depressive symptoms (Do et al., 2013; Durkin and Barber, 2002; Kim and Health, 2012). Based on this evidence, it appears that the association between screen time and mental health may be curvilinear.

There are other investigations which have quantified the screen time for various electronic devices. A systematic review examined mental health and the use of mobile phones and other wireless devices (e.g., tablets and smartphones) among adolescents (under 18 years old), and included 25 observational studies (10 cohort studies and 15 cross-sectional studies) (Girela-Serrano et al., 2022). The review findings illustrated that higher frequency and longer duration of use of mobile phones and other wireless devices may be associated with poorer mental wellbeing, worse anxiety and depressive symptoms in children and adolescents (Girela-Serrano et al., 2022). A systematic review by Santos et al. (2023) also explored the association between mobile phones and screen use, and mental health and wellbeing (50 studies; 38 cross-sectional studies and 12 longitudinal studies, including 1900447 adolescents aged 12-18 years). The results showed that most studies found a negative association

between screen time (involving smartphones, computers or video game consoles) and adolescent mental wellbeing, particularly, smartphone use (mainly over 2 hours per day) was associated with reduced mental wellbeing. Regarding usage time on a computer or the Internet, most studies reported an increased risk of depressive symptoms with increased use. The Hoare et al. (2016) systematic review also stated a curvilinear relationship between usage time and depressive symptoms, namely moderate or low level usage (lower than 2 hours per day) may be associated with lower level of depressive symptoms, compared with no usage.

In terms of the associations between social media use and mental health problems, there are a series of studies that have explored this issue. A scoping review of studies exploring the relationship between social media use and mental health in adolescents (age 13-19 years), identified 79 studies, 94% of which were quantitative (Schønning et al., 2020). Although included studies had different measures of social media use, overall the results showed a correlation between more frequent social media use and poorer mental health outcomes (Schønning et al., 2020). Another systematic review focusing on 13-18 year old adolescents, including 12 cross-sectional studies and one longitudinal study, indicated problematic social media use, more social media activities (e.g., frequency of social media checking, more social media accounts), increasing time spent on social media, and addiction to social media may be associated with higher risk of anxiety, depression and psychological problems (Keles et al., 2020). A review by McCrae et al. (2017) synthesised evidence on the relationship between social media usage time and depressive symptoms in children and adolescents aged 5 to 18 years, and of the 11 included studies, 8 were conducted in high income countries. McCrae et al. (2017)'s review included a meta-analysis which showed a

weak but statistically significant association (overall random-effects pooled estimate was 0.13, p = 0.001) between social media usage time and depressive symptoms in adolescents. Another meta-analysis of 12 studies (11 studies conducted in high-income countries) explored the association between social media usage time and depressive symptoms among 11-18 year-old adolescents, and found a small but significant correlation between them (r=0.11, p<0.01) (Ivie et al., 2020). Similar findings were also reported in a narrative review of reviews by Orben (2020) on adolescents' mental health, screen time and social media (23 reviews). In this review, the association between social media usage time and psychological wellbeing was reported as being negative overall, but the magnitude of this association was very small. Weak associations between time using social media and screens, and poor mental health were also reported in a review by Tang et al. (2021); this review included 35 longitudinal studies up to August 2020, selected on the basis of criteria including young people aged 10 to 24 years, followed up over a period of at least 6 months. The review included 23 studies on depression, 10 on anxiety, and 4 on self-esteem. Nearly half of the studies were conducted in the US (14 out of 35), with sample sizes ranging from 126 to 12866 participants. Screen categories included in the studies were total screen time, TV, computers, mobile phones, and social media. The results found a small, albeit significant, association between all screen categories, including social media time, and subsequent depressive symptoms. Overall in this review, social media use was negatively correlated with mental health problems, albeit some associations were of small magnitude (Tang et al., 2021).

Some inconsistent findings have been reported in current evidence exploring associations between social media and mental health problems. In a narrative review

of reviews (containing 23 reviews of medium and high quality), Odgers and Jensen (2020) stated that findings of individual studies within the review were not consistent, with a mixture of positive, inverse, or non-associations between social media use and mental health problems reported. Non-association also appeared in a study by Coyne et al. (2020), which was an 8-year longitudinal study exploring the association between time spent using social media and depression and anxiety in adolescents. Participants included 500 US adolescents aged 13 to 20 years, who completed annual questionnaires. The results showed that increased time spent on social media was not associated with increased depression or anxiety during the adolescent developmental period. Another point that deserves notice was highlighted in a review by Keles et al. (2019), in which they suggested that specific attitudes or behaviours during social media use (e.g., social comparison) may also have an influence on the symptoms of depression, anxiety, and psychological distress, however, these aspects of social media use have not been investigated.

1.5.2 Relationship between social media use and mental health: qualitative evidence

There are fewer qualitative studies exploring the association between social media and mental health. Some qualitative studies mention the potential risks from social media on adolescents' mental health. A study was conducted with six focus groups of 54 British adolescents aged 11 to 18 years and found that adolescents felt that social media was a threat to mental health, it was a potential platform for cyberbullying, the use of social media was addictive, and that social media caused them to develop mood and anxiety disorders (O'Reilly et al., 2018). Similarly, Popat and Tarrant (2022), in a narrative qualitative literature review involving 24 qualitative studies of adolescents

aged between 13 and 17 years, explored mental wellbeing in relation to social media use among adolescents. The results indicated that social media use contributes to poor mental health through worries about others' opinions, exclusion by some groups, privacy concerns, pressure to stay connected, physical comparison, addiction, and cyberbullying. In addition, this study reported the positive impact of social media on adolescents' mental health through opportunities for social engagement and peer support, and in relation to the development of closer connections with people who experienced similar conditions (Popat and Tarrant, 2022). The positive role of social support via social media in relation to mental health was also reported by Vaingankar et al., (2022). Eleven focus groups with adolescents from different ethnicities (age 15-24 years) in Singapore also provided evidence that supported the positive mental wellbeing aspects of social media, such as connection with friends and a global community, engagement with social media content, and social media as an outlet for expression (Vaingankar et al., 2022).

1.5.3   Summary

The associations between social media use and mental health-related problems are complex and often inconsistent, with a mixture of positive, negative, and null findings reported across studies. Social media provides interactive functions compared to traditional media. This new and more interactive form of media use is likely to impact differently on health-related outcomes compared with traditional media and passive screen time. In quantitative studies, non-linear associations with mental health-related outcomes were often reported. In general, less than 2 hours social media use may be

beneficial to mental wellbeing, although there is no precise level of usage time that is associated with worsening mental health outcomes.

Qualitative studies provided some explanations for associations between social media use and mental health. Potential negative impacts on adolescents' mental health were related to cyberbullying, accountability of keeping connected, physical comparison, indulgent behaviours on social media, and worries about others' opinions. On the other hand, qualitative studies also presented benefits of social media use to adolescents' mental health, such as social and peer support. Overall, the current evidence based on social media use and mental health is mixed and inconclusive.

1.5.4 Relationship between screen and social media use and sleep problems: quantitative evidence

People spend more than 30% of their lifetime sleeping or endeavouring to do so (Colten and Altevogt, 2006). Existing studies found that children and adolescents who reported shorter sleep duration showed poorer processing speed, sustained attention, memory, and executive function in learning and daily life (Gradisar et al., 2008; Sadeh et al., 2002; Steenari et al., 2003). In addition, poor sleep has been linked to poor immunity, physical health problems such as colds and headaches, obesity and emotional problems such as anxiety, depression, and suicidal thoughts (Chaput et al., 2016; Henderson et al., 2019; Shochat et al., 2014). Sleep is especially important for adolescents who are experiencing rapid growth and cognitive development (Galván, 2020; Tarokh et al., 2016).

The American Academy of Sleep Medicine has recommended that children aged 6–12 years should regularly sleep 9–12 hours per 24 hours and adolescents aged 13–18 years should sleep 8–10 hours per 24 hours (Paruthi et al., 2016). According to data from the Centres for Disease Control and Prevention (CDC), the prevalence of short sleep duration among 13-14 years old was 20.1% (CDC, 2022), rising in high school students (age 14-18) to 77.9% in 2019 (CDC, 2022). According to the 2019 China Youth and Children Sleep Index White Paper, a survey of 65648 6-17 year-olds, among the secondary school students (age 13-17 years), only 18.9% slept for more than 8 hours per day, and up to 59.4% slept for less than 7 hours, with an average sleep time of 6.82 hours (i.research, 2019).

A systematic literature review by Hale and Guan (2015) examining overall screen time and sleep in children aged 5-17 years reported that in 60 of the 67 included studies there was an adverse association between unspecified screen time and at least one sleep outcome, especially duration of sleep. The remaining studies reported no association between screen time and sleep problems (Hale and Guan, 2015). Another systematic review and meta-analysis synthesised evidence from 17 studies on the relationship between electronic device use during bedtime and sleep problems in children and adolescents aged 6-19 years. They found that use of electronic devices at bedtime was associated with higher risk of daytime sleepiness (odds ratio 2.72, 95% CI: 1.32-5.61) and poorer quality sleep (odds ratio 1.46, 95% CI: 1.14-1.88) compared to those who less frequently used electronic devices at bedtime (Carter et al., 2016). A systematic review including 49 quantitative studies (3 randomized controlled trials, 2 quasi-experimental studies, 15 prospective cohort studies and 29 cross-sectional studies) from Western countries explored the effect of different electronic devices

(such as mobile phones, TVs, computers, and tablets), screen time, and social media use on sleep among 0–15-year-old children and adolescents (Lund et al., 2021). Among 6–12-year-old children, the evidence suggested associations of electronic media use with delayed bedtime and poor sleep quality. For 13–15-year old adolescents, there were associations between screen time and problems falling asleep, and between social media use and poor sleep quality (Lund et al., 2021).

Considering specific electronic devices, one review (36 studies) focused on adolescents' (age 5–17 years) sleep and its relationship with different types of electronic media (television viewing, use of computers, electronic gaming, the Internet, and mobile telephones) (Cain and Gradisar, 2010). The authors reported that delayed bedtime and shorter total sleep time were found to be consistently related to use of all types of electronic devices (Cain and Gradisar, 2010). This finding was also supported by Mei et al. (2018), who conducted a systematic review (23 cross-sectional studies) and meta-analysis (19 of the 23 studies), including studies from Europe, East Asia, and West Asia and involving 253904 adolescents with a mean age of 14.82. Mei et al. aimed to explore problematic internet use (PIU), excessive use of computers, mobile phones, MP3 players, tablets, games consoles and TV, and sleep problems. The meta-analysis showed that the odds ratio of the association between excessive use of these electronic devices or problematic Internet use and poorer sleep quality was 1.33 (95% CI, 1.24-1.43). The standardized mean difference (SMD) in sleep duration between those with excessive use of these electronic devices or problematic Internet use and those without and was - 0.25 (95% CI. -0.37, -0.12). Overall, excessive time spent on electronic devices was related to poorer sleep quality and shorter sleep duration.

Several primary studies have found a negative relationship between television viewing and a variety of sleep variables (Adam et al., 2007; Li et al., 2007; Saarenpää-Heikkilä et al., 2000; Toyran et al., 2002). In summary, watching television is associated with reduced total sleep time, increased sleep anxiety, and an increased level of overall sleep disturbance. However, a longitudinal study conducted by Johnson et al. (2004) showed a 'non-harmful' level, namely adolescents who watched television for less than 1 hour per day, were less likely to have sleep problems at follow-up compared to those who viewed for over an hour. Regarding computer use, frequent use of computers or electronic games has been reported to be associated with shorter total sleep time (Li et al., 2007; Van den Bulck, 2004; Adam et al., 2007; Punamäki et al., 2007) and higher levels of daytime tiredness (Van den Bulck, 2004). In relation to the association between mobile phones and sleep problems, a large Australian cross-sectional survey involving 252195 adolescents (age 8-18 years) showed that children and adolescents of all ages who used mobile phones at night were less likely to achieve the recommended 8 hours of sleep (Correa et al., 2022). In connection with this, most studies report that increased mobile phone use is associated with increased sleep problems (insufficient sleep and daytime sleepiness), although sometimes the association are weak (Gaina et al., 2005; Söderqvist et al., 2008; Yen et al., 2008).

Considering the relationship between social media and sleep, consistent results have been reported across studies, with increased social media use being associated with more sleep problems. Evidence from thirty-six cross-sectional studies and six prospective cohort studies examining 16 to 25 year-old youth was synthesised in a systematic review by Alonzo et al. (2021). The authors reported significant associations between excessive social media use, and poor mental health and poor

sleep in all studies. Hisler et al. (2020) explored the association between social media use and sleep duration in 13–15-year-old adolescents in the UK. They reported a weak inverse association which was stronger after controlling for confounders (sex, age and family incomes). A study of older adolescents in Singapore also reported that increased social media use was associated with decreased sleep quantity and increased daytime sleepiness (Nasirudeen et al., 2017). In a study of Indonesian adolescents, Nursalam et al. (2019) showed that positive associations between duration of social media use and insomnia exist. They also explored frequency and types of social media use, but found no association between these social media measures and insomnia (Nursalam et al., 2019). A study by Scott et al. (2019) used data from the UK Millennium Cohort study (a large, representative UK cohort) to explore the relationship between social media use and sleep, and revealed that more time spent on social media (over 3 hours per day) was associated with poorer sleep patterns.

1.5.5 Relationship between social media use and sleep problems: qualitative evidence

A few qualitative studies have explored how social media use or screen time has a negative impact on sleep in adolescents. A systematic review and thematic synthesis using data from 14 studies including 967 participants (age 10–24 years) identified three main themes, namely social motivation, habitual social media use, and perceptions of the issue itself (negative effects, restriction of screen time, and distractions from other priorities) (MacKenzie et al., 2022). Regarding social motivation, adolescents were actively involved in online social interactions, and even though they recognised the importance of sleep, they did not consciously stick to their sleep

schedule. Adolescents feared that when they were asleep that they may 'miss out' on important social activities, where participation in online groups was perceived as an obligation (MacKenzie et al., 2022). Regarding habitual social media use, adolescents reported that they had no control over their behaviour and found it difficult to stop using electronic devices, even at the expense of sleep. When these adolescents were engaged with social media, time awareness disappeared, and sleep plans were not followed (MacKenzie et al., 2022). In terms of negative effects, adolescents were aware that social media use can delay sleep, with a range of effects including tiredness and adverse effects on academic performance. Adolescents themselves and their guardians took action like attempting to limit the use of electronic devices to reduce the negative impact from it, based on the fact that social media can interfere with other priorities such as homework (MacKenzie et al., 2022). Interestingly, adolescents' opinions towards sleep and social media use varied, some adolescents claimed bedtime social media use actively facilitated their sleep, as the usage of social media was considered a ritual of relaxing in pre-bedtime (MacKenzie et al., 2022). Another study conducted three focus groups with adolescents (age 14–18 years) in the US from a mix of ethnicities and identified how mobile phone use acts as a barrier to sleep hygiene and habits. For example, adolescents claimed that social media disrupted sleep routines on weekends, and their minds were kept active due to interaction with peers on social media at bedtime (Quante et al., 2019).

1.5.6   Summary

Unlike the studies of screen and social media use and mental wellbeing, there was less evidence of a U-shaped association between screens and social media use, and sleep. Only one study reported that adolescents with less than one hour of TV time

were less likely to have a range of sleep problems. The majority of studies indeed showed the inverse associations between screen time, electric devices, and social media use and sleep problems (duration, quality, and daytime sleepiness), but some studies among them only presented a weak negative association.

In terms of qualitative research, studies demonstrated how social media use deprives adolescents of sleep, for example by fearing that falling asleep might result in 'missing' important social activities, or that time awareness becomes less when fully engaged in social media. The detrimental effects of social media interrupting sleep manifest themselves in terms of fatigue and impact on academic performance. Meanwhile, several studies reported that measures (such as self-management and guardian supervision) can be used to mitigate the adverse effects of social media use on sleep. Interestingly, some themes illustrated how adolescents perceived bedtime use of social media as a way to relax and calm down before going to bed and to promote their sleep.

1.5.7 Relationship between screen and social media use and physical activity (PA): quantitative evidence

It is well known that leading a physically active lifestyle during adolescence is good for adolescent health in the short and long term (Department of Health Human Services, 2018; World Health Organization, 2010). Benefits include improved bone and cardiometabolic health, increased cardiorespiratory and muscular fitness, and favourable impacts on mental wellbeing and sleep quality (Department of Health Human Services, 2018; Wang and Boros, 2021). The World Health Organization (WHO) recommends that children and adolescents aged between 5 and 17 years

engage in at least 60 minutes of aerobic physical activity per day (WHO, 2022). However, a multi-national study of adolescents from 146 countries identified that 81% of adolescents do not meet these guidelines (Cla, 2018; Guthold et al., 2020).

In a large survey of 24800 participants, conducted in the US, approximately 20% of adolescents used screen devices for more than 5 hours per day, and this level of use was associated inadequate physical activity (Kenney and Gortmaker, 2017). In a meta-analysis of 163 studies in adolescents aged 12-18 years, the findings showed that there was an inverse association between screen time, TV use and computer use, and physical activity, but this was weak and the majority studies were conducted in US and Europe (Pearson et al., 2014).

A survey of adolescents aged 18 years in the US and Thailand on smartphone use (Penglee et al., 2019) found that greater time using a smartphone per day was inversely associated with the number of days per week engaging in physical activity. However, this was only observed among Thai adolescents and not American adolescents. US adolescents had a longer duration of physical activity and heavier intensity of physical activity compared with adolescents from Thailand. At the same time, the study found that more US adolescents used smartphones to browse the content related to health and exercise than Thai adolescents. Similar findings were found in Spanish adolescents. In a cross-sectional study conducted in Spain with 501 secondary school students (age 12-18 years), the results showed users who had higher scores for problematic use of mobile phones (measured by the Mobile-Related Experience Questionnaire (Muñoz-Miralles et al., 2016) had poor physical activity

engagement (the performance of jump, run and lifting test) compared with those with low scores for problematic mobile phone use (Bravo-Sánchez et al., 2021).

Overall, there is limited research evidence relating to association between social media use and physical activity. There are three cross-sectional studies exploring this, one conducted in the US, one in Canada and one in Australia. Sampasa-Kanyinga and Chaput (2016)'s cross-sectional study involving 9,388 students in grades 7 to 12 (age 12-18 years) in Canada found that male adolescents were more likely to meet physical activity recommendations (e.g., >= 60 minutes of moderate to vigorous physical activity per day) if they were infrequent social media users (less than 2 hours per day). In a cross-sectional study based in the US by Shimoga et al. (2019), they divided students into different groups according to different usual physical activity levels and looked at the relationship between social media use and the likelihood of doing vigorous daily exercise. Among physically active students, frequent social media use (using social media almost every day) was associated with a higher likelihood of vigorous daily exercise, however, among sedentary students, frequent social media use was associated with a lower likelihood of vigorous daily exercise. Among moderately active students, moderate social media use was associated with the highest likelihood of doing vigorous daily exercise. This relationship showed that a moderate amount of social media use may have a positive impact in those with moderate or high existing physical activity levels. Finally, a survey study including 1188 Australian adults and 963 adolescents (mean age was 16.2 years) explored associations between physical activity-related social media use (e.g., streaming services for exercise subscriber fitness programs via apps etc.) and adherence to physical activity guidelines (Parker et al., 2021). The results showed that adolescents

who used streaming services for physical activity via social media engaged in higher moderate to vigorous intensity physical activity and muscle-strengthening exercise compared to adolescents who did not use physical activity-related social media (Parker et al., 2021).

1.5.8 Relationship between social media use and physical activity: qualitative evidence

Qualitative studies related to social media and physical activity have tended to explore how social media (or specific apps) have brought positive and negative influences on adolescents' physical activity-related outcomes. In a large multi-method qualitative study in the UK that engaged 1296 adolescents (age 13-15 years), findings showed that social media sites provided specific health-related information to adolescents, but adolescents were concerned about whether this health information is provided by reputable social media accounts. On the other hand, adolescents created their own health-related content. In addition, social media offers interactive features such as liking to allow adolescents to interact with the postings like health-related information and body image (Goodyear et al., 2019a). In summary, the results identified five forms of social media content that influenced adolescents' health-related behaviours, inclusive of physical activity: automatically sourced content; suggested or recommended content; peer content; likes; and reputable content (Goodyear et al., 2019a).

Further qualitative studies exploring relationships between screens or social media and physical activity have reported on motivation and negative factors in relation to physical activity. A study consisting of two focus groups explored the components that

could make smartphone apps more appealing to adolescents from Luxembourg and investigated the attitudes and preferences of adolescents between the ages of 16 and 18 years towards various features of apps related to physical activity (Domin et al., 2022). The features of goal setting and planning, coaching and training programs, activity tracking, feedback, and location tracking were found to be attractive, motivating, and interesting to adolescents (Domin et al., 2022). However, features such as mood and sleep tracking, sharing workout results via social networks, digital coaches, and rewards were perceived negatively by the adolescents, who found them to be useless and not motivating (Domin et al., 2022). Furthermore, the reminders component and automatic activity recognition feature were seen as useful (Domin et al., 2022). Other studies have focused on using social media as a way of positively influencing adolescents' physical activity. A qualitative study containing 6 focus groups explored the feasibility of using social media to increase physical activity in Australian adolescent girls (age 13-18 years), and found that online social networks (e.g. Facebook) were perceived as an effective way to improve physical activity among this population (Van Kessel et al., 2016a). Improvements to engagement with physical activity were attributed to the benefits of physical activity being highlighted on social media, or when there were opportunities for friendly competition, goal setting, and teamwork (Van Kessel et al., 2016a). Furthermore, adolescents expressed a desire to receive high levels of feedback when exercising, such as feedback on their own performance and notification of their friends' achievements (Van Kessel et al., 2016a). However, the participants mentioned that as the novelty of sporting content on social media wore off, it was difficult to stay interested in sporting activities and specific apps, and that time for physical activity sometimes competed with part-time work, school, and homework (Van Kessel et al., 2016a).

1.5.9 Summary

Compared with quantitative research focused on screen time, electronic devices, social media use, mental health, and sleep problems, the studies exploring the association between screen time, electronic devices, social media use, and physical activity among adolescents were not as rich and expansive. Mainly, three quantitative studies provide an understanding of the potential association between social media use and physical activity among adolescents, but their findings are inconsistent. A limitation of the current qualitative evidence is that these studies mainly explored social media use and health-related behaviours in general (such as nutrition, diet, body image), rather than social media use specifically in relation to physical activity. Also, some qualitative studies have focussed on how social media positively and negatively affects adolescents' physical activity, but there is no detailed exploration of how adolescents specifically interact with physical activity content on social media. Across both types of studies, there is a limited understanding of how social media use influences physical activity behaviours, and the contextual factors that drive social media use in relation to physical activity. Thus, there is a need to better understand adolescents' uses of social media in relation to physical activity, to potentially inform future approaches to encouraging physical activity in this age group.

1.5.10 Studies conducted in China

Some studies have been conducted in China on the association between health-related problems and screen time. There was a systematic review containing 252 studies (202 studies were published in Chinese, 50 studies were published in English) on Chinese children and adolescents aged 6–18 years, to explore associations

between a number of health-related problems (e.g., psycho-behavioural problems, adiposity, myopia, poor academic performance, cardiometabolic disease risks, sleep disorder, poor physical fitness) and screen time. Twenty-one studies (13 in Chinese and 8 in English) were included in a meta-analysis (Zhang et al., 2022). They found that several health-related problems were associated with screen time, and that screen time of over 2 hours per day was associated with more severe psycho-behavioural problems (Zhang et al., 2022).

Regarding mental health, in a cross-sectional study with 11831 adolescents (mean age was 15 years) conducted in Shandong, China, mobile phone use of ≥ 2 hours per day on weekdays and ≥ 5 hours per day on weekends was associated with an increased risk of depressive symptoms (Liu et al., 2019). Similar results were also found in a study by Wang et al. (2021), which reported that over 2 hours per day of screen time was positively associated with depressive symptoms in adolescents aged 11 to 18 years. A longitudinal study of 5365 students in the 7th and 8th grades (mean age was 13.9 years) from nine secondary schools in Guangzhou, China showed that addictive online social media use was associated with increased depressive symptoms at follow up after 9 months (Li et al., 2018). Furthermore, this study showed that adolescents who were depressed at baseline but not addicted to social media were more likely to have addictive social media use at follow-up than those who were not depressed (Li et al., 2018).

Considering sleep problems, a cross-sectional study conducted in Ningbo China which included 3020 students in 7th to 11th grades at four secondary schools (age 12-16 years) found that sleep duration was significantly shorter, and sleep onset latency was

significantly longer in those students who used mobile phones before sleep, compared with those who either sometimes or never used mobile phones before sleep (Mei et al., 2019). Another cross-sectional study also provided evidence that mobile phone addiction was significantly associated with poor sleep quality among 1258 young people aged 14 to 20 years (Liu et al., 2017).

In terms of physical activity, Dong et al. (2021) highlighted in their cross-sectional study that more TV time had a significant correlation with less physical activity among adolescents (mean age was 14.4 years), but no association was been found between the amount of time spent playing computer or video games and physical activity. A cross-sectional study of 2625 junior and senior high school students (age 12-18 years) in Wuhan, China, showed that watching more than four hours of television on a school day was negatively associated with physical activity (defined as vigorous exercise on 3 or more days per week) (Yan et al., 2017). The study reported different findings when looking at weekends; social media use was associated with increased physical activity at weekends when the duration of use was between 2 and 4 hours (Yan et al., 2017).

1.6 The limitations of the previous studies

In this introductory chapter, I have provided an overview of the evidence for associations between screen use, social media and health-related outcomes (mental health, sleep, and physical activity). This section will explain the limitations of previous studies.

1.6.1 Study methods and settings

The majority of studies exploring relationships between screen and social media use, and health and wellbeing outcomes are cross-sectional, which means the causality of observed associations cannot be confirmed and it is not possible to rule out reverse causation. There have only been a few longitudinal studies which have focused on causation. Overall, most of the research to date has been conducted in Western countries, and limited research has been conducted in China. As social media is prevalent in China, and its uses are unique to this context, there is a need to explore social media use in further detail in China. Furthermore, and based on different situations in different countries, the evidence in Western contexts may not be applicable to a larger and more diverse population of China. That said, this chapter has provided some emerging evidence. Notably, studies of cross-sectional design are valuable in helping us determine the nature of adolescents' social media use and explore relationships with health and wellbeing, which generate hypotheses for further research.

1.6.2   Measurement of social media

The measures used to assess social media is another limitation. Most existing studies have focused on time spent using social media, which is only one aspect of social media use. It may also be important to assess frequency of social media use, what types of social media adolescents engage with, and their reasons for using different types of social media.

1.6.3   Timeliness of the study

Many of the studies discussed in this chapter were conducted several years ago, and given the exponential growth in adolescents' screen and social media access and use in the last decade, the credibility of the existing evidence in the current context needs to be considered. Earlier studies may not be representative of the current situation. According to a research report in 2015 (Common Sense Media, 2015), American adolescents aged 13-18 years spent on average over 6 hours per day using screen devices. This is substantially more than the recommended screen time (2 hours daily) from the American Academy of Pediatrics (Strasburger et al., 2013). However, this recommendation is controversial, as there is not yet consensus, based on previous evidence, that more than two hours of social media or screen time is harmful or linked to more health problems. Over time, Chief Medical Officers in the UK have introduced various recommendations on social media use and screen time. In 2019, the Chief Medical Officer brought in recommendations that were no longer limiting themselves solely to the time of use, but instead suggesting more detailed and actionable measures, such as leaving mobile phones outside of the bedroom at bedtime, ensuring that teenagers are screen-free at mealtimes, and using the functionality of an electronic device to track screen or social media time for monitoring purposes (Davies et al., 2019). Furthermore, habits and preferences for social media use among adolescents keep changing over time. Therefore, the latest research on social media and health in adolescence needs to be further developed and updated.

1.6.4 Variations in social media use and health outcomes across different groups

Another gap in the literature is that there is very little exploration of the differences in associations between social media use and health outcomes across different gender

or age groups. Some studies have reported differences in adolescents' social media use across these groups, suggesting different groups have different ways of using social media (Anderson and Jiang, 2018a; Madden et al., 2013; Rideout et al., 2021), and so further exploration of health effects of social media across these different groups is warranted. According to the Pew Centre's study in 2015, boys and girls like to participate in different programs (play games, watch videos etc.), as well as having different preferences for various social media applications (Lenhart et al., 2015). There is evidence to suggest that girls and boys have different motivations of social media use. For girls, social media is a good platform to enhance pre-existing friendships; for boys, social media provides opportunities to make new friends (Lenhart and Madden, 2007a). A longitudinal analysis of 17409 British young people (age 10-21 years) showed that there was a distinct window for boys and girls towards the influence of longer social media use during adolescence on the decline in life satisfaction in the following year. Though both of them may be affected, this window happened in girls aged 11-13 and in boys aged 14-15 (Orben et al., 2022). Social media use also differs with age, not only regarding time and frequency of use, but also relating to sharing different contents (Lenhart and Madden, 2007b; Lenhart et al., 2015). Young people's use of social media has different characteristics and needs, according to the Ofcom UK 2023 report. Children aged 8-11 years are developing media skills and are slowly starting to engage in online activities without parental intervention. Adolescents aged 12-15 years are described as connecting and creating through media, with the majority of children communicating with others, tending to create and share content on social media. Adolescents aged 16-17 years are expanding further into the social media sphere and are using more diverse applications (e.g., Facebook, Twitter, and Pinterest) (Ofcom.UK, 2023). Most studies have focused on older adolescents (age 18 years),

early adolescents (age 10-13 years), or middle adolescents (age 14-17 years) (Allen and Waterman, 2019), rather than exploring wider age ranges and comparing different age groups within these. Moreover, the younger age group needs to be more studied, as they are usually 'new' social media users. Exploring differences between different age and gender groups will help us more fully understand the health implications of social media.

1.6.5   Qualitative studies in physical activity

Previous qualitative studies have explored the influence of social media on health-related outcomes, such as diet, body image and physical activity, and health information gained from social media (Burnette et al., 2017; Goodyear et al., 2019a). However, there are limited qualitative studies specifically exploring relationships between social media use and physical activity. Social media has many affordances that allow users to acquire diverse information about health and physical activity in accessible ways. For example, there are apps, tablets, smartphones and wearable devices that support adolescents to engage with and monitor their engagement with physical activity (Gard, 2014; Goodyear et al., 2019b; Goodyear et al., 2021a). Qualitative evidence that explains relationships between adolescents' uses of social media and how this may influence physical activity are limited, and there has been almost no qualitative exploration of this in China.

1.6.6   Relevant mediators of associations

Most evidence relating to mediators of relationships between social media use and health exist in the area of mental health. Kelly et al. (2018) provided evidence to

suggest that social media use was associated with poor sleep and low self-esteem, which in turn were related to depressive symptoms. Furthermore, a 2-year longitudinal study conducted by Raudsepp (2019) reported a similar finding; in this study problematic social media use and sleep disturbances related to social media use both significantly predicted a change in adolescent depressive symptoms (explaining 29% of the variance in the slope of depressive symptoms). Similarly, Rutter et al. (2021) showed that physical activity was a mediator in the associations between social media use and mental health problems. Social media use was associated with greater depression and anxiety symptoms, while increased physical activity was associated with reduced depression and anxiety symptoms, and in turn, physical activity partially moderated the relationship between social media use and depression and anxiety (Rutter et al. 2021). Apart from the exploration of factors mediating the association between social media use and mental health, some studies have explored potential mediators of the association between sleep problems and social media. According to Woods and Scott (2016), adolescents who used social media more experienced poorer sleep quality, which was mediated by lower self-esteem and higher levels of anxiety and depression. In terms of the relationship between social media use and physical activity, there has been very little exploration of potential mediating factors. Thus, there is a need to better understand which factors may mediate the association between social media use and physical activity.

1.7 Setting for the thesis

The research for this thesis was conducted in Hefei City, Anhui Province, China. China, officially the People's Republic of China (PRC), is located in East Asia. As of 2022,

China has a population of around 1.41 billion, which is the largest population of any country in the world (Statista, 2022b). According to the World Bank classification (The WorldBank, 2023), China is considered an upper middle-income country. Anhui is a provincial administrative region of the people's Republic of China. It is located in the Yangtze River Delta, East China, with a total area of 140100 square kilometres (Anhui.gov, 2022). As of the end of 2022, Anhui Province has 16 provincial cities, 9 county-level cities, 50 counties, 45 municipal districts, and 61.27 million residents (Anhui.gov, 2022).

Hefei, the capital of Anhui Province, is also the sub-central city of China's Yangtze River Delta urban agglomeration approved by the State Council. It is an important national scientific research and education base, modern manufacturing base and comprehensive transportation hub (GOV.cn, 2016). As of 2022, the city has four districts, four counties and one county-level city under its jurisdiction, with a total area of 11445.1 square kilometres, an urban area of 528.5 square kilometres, a resident population of 9.634 million, and a 84.64% urbanization rate (Hefei gov, 2016; Hefei Bureau of Statistics, 2022). The urbanization rate is the proportion of the total population who live in urban areas (including agricultural and non-agricultural). In 2021, the urbanisation rate of the United States was 82.66% (Statista, 2021a); that of the United Kingdom was 84.15% (Statista, 2021b); and that of China was 64.72% (Statista, 2023). In 2022, Hefei City achieved a regional GDP of 1.20131 trillion RMB, and a per capita GDP of 125798 RMB.I It ranks 21st among 337 major cities above prefecture level in China in terms of its GDP (Hefei Bureau of Statistics, 2022). Hefei is also on the list of 15 new first tier cities of China (YICAI.CN, 2023). First-tier cities represent the most developed regions in China, for example, Beijing, Shanghai, Guangzhou and

Shenzhen. The 15 new first tier cities represent flourishing cities with booming economic, cultural and other strengths (YICAI.CN, 2023). Maps showing the locations of Anhui and Hefei are presented in Figure 1.

Figure 1 Maps showing the position of Anhui Province and Hefei City in China (Kong et al., 2022)
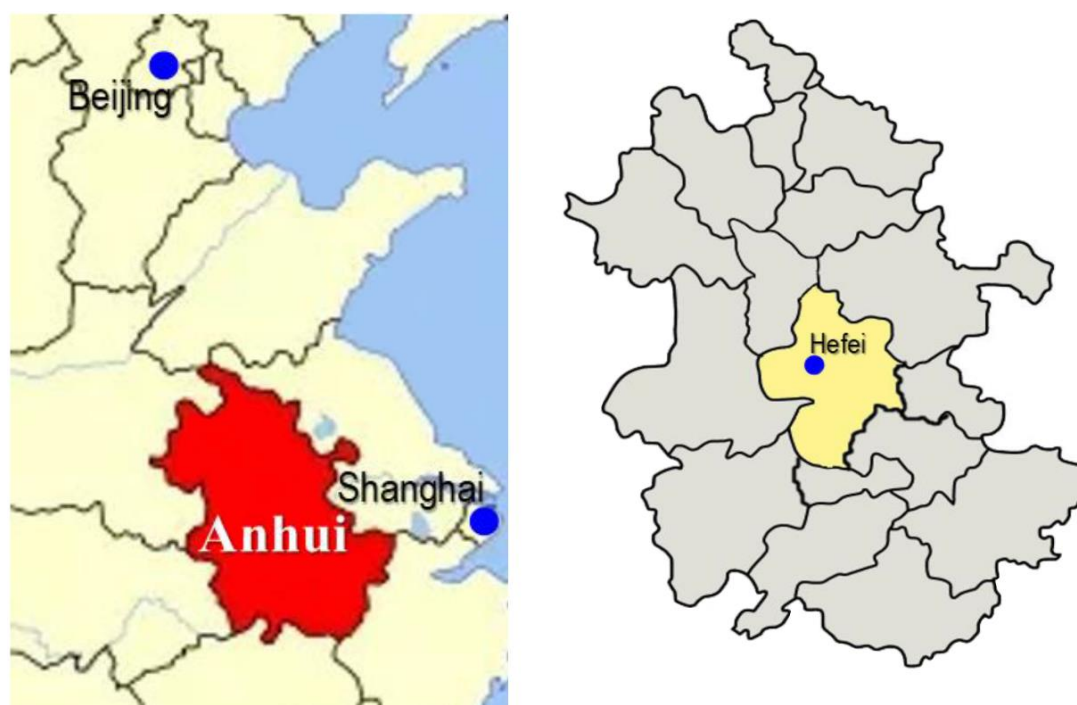
1.7.1   School contexts in Hefei
1.7.1.1   Public vs private

Public schools refer to the schools funded by the government or the local bureau of education, which have economic and political government support. The registration requirement of public schools is that the student's family living place and the address of property ownership certificates should be the same district as the school.

Private schools refer to the schools founded by private corporations, which may partly take profit into the consideration of running a school. Pre-registration and passing the entrance examination are important processes of entry to private schools, but there is no restriction on the living location. Due to the self-financing arrangements, the fees of private schools are generally higher than public schools, although public school pupils also need to pay some fees to cover costs of books and equipment.

1.7.1.2   Boarding vs non-boarding

Boarding schools may be public or private schools. Boarding schools for students of younger ages have become much more common in China in the last five years. Originally, boarding schools were mainly high schools (16-18 year-old adolescents attend high schools in China), but now there are more junior boarding schools that admit adolescents aged 12-15 years. Boarding schools are seen to be conducive to the cultivation of students' independence, and stricter rules are in place relating to students' behaviour (Bass, 2014; Devine, 2005). The management of boarding schools is such that all study, leisure time, and extracurricular activities of students are carried out in the school from Monday to Friday. Students are able to go home for two days on weekends. In non-boarding schools, students go to school and go home after the school day. Following school study and/or extracurricular activities, after-school study and life are based at home.

In relation to the management of electronic devices and social media, boarding schools prohibit the use of electronic devices at all times that the students are present at the school, including before and after school on weekdays (but some students will

still use them). Similarly, adolescents at non-boarding schools are not allowed to use electronic devices during school hours (but some students will also take smartphones to class), but obviously there are no restrictions on these students outside of school hours.

1.8 Thesis aims and objectives

The aim of this thesis is to explore the nature and extent of screen time, electronic devices and social media use in adolescents aged 12-15 years in China, and to examine the associations between these and a range of health outcomes: mental health, sleep problems and physical activity. The thesis then explores in more depth the relationship between social media use and physical activity. This is a mixed-methods study consisting of both quantitative and qualitative elements.

1.9 Overview of chapters

The thesis consists of quantitative and qualitative studies and a mixed method synthesis.

Chapters 2, 3, and 4 focus on the quantitative, cross-sectional study. The aims and methods are covered in Chapter 2. Chapter 3 presents the results of the study and is divided into three sections. In section A, the descriptive analyses of the data on social media use, mental wellbeing, sleep and physical activity are presented. In section B, the associations between screen time, mobile phone and social media use, and mental wellbeing, sleep and physical activity are presented. In section C, an exploration of the

potential mediating factors between social media use time and physical activity time are presented. Chapter 4 presents a discussion of the three sets of quantitative results.

Chapter 5 presents the qualitative study. This study focuses on social media use in adolescents and how they use it in relation to physical activity.

Chapter 6 presents a mixed-method study used to integrate the results of quantitative and qualitative studies that relate to adolescent social media use and physical activity.

Chapter 7 summarizes the whole thesis, bringing together the main findings and discussing their implications and directions for future research.

CHAPTER 2 SCREEN TIME, ELECTRONIC DEVICE AND SOCIAL MEDIA USE AMNG TEENAGERS IN CHINA: AIMS AND DATA COLLECTION METHODS OF CROSS-SECTIONAL STUDY

2.1 Aims and objectives

This chapter focuses on the methods for a cross-sectional survey, comprising the quantitative dimension of the study. The objectives of the cross-sectional study, in Chinese adolescents, are to:

1. Determine the amount of screen time on different electronic devices and overall

2. Explore the number and types of electronic devices used

3. Explore social media use (duration, frequency, type etc.), and reasons and motivations for use

4. Assess sleep (duration and quality), mental health (mental wellbeing, depressive and anxiety symptoms) and physical activity (weekly leisure time activity and numbers of days adolescents are physically active for at least 60 minutes)

5. Explore relationships between screen time, mobile phone use and social media use, and mental health, sleep and physical activity

6. Explore potential subgroup differences in associations between social media use and physical activity

7. Explore potential factors mediating relationships between social media use and physical activity.

2.2 Study design and data collection methods

A cross-sectional study was conducted with school-aged adolescents, collecting self-reported data on screen time, electronic devices, social media use, and measures related to mental health, wellbeing, sleep, and physical activity, using an online survey.

2.2.1   Sampling method

Data collection took place in the region of Hefei, China. Hefei has a main urban area, four counties and one county-level city. There are 238 secondary schools in Hefei; 89 in the Main Urban Area, 27 in Changfeng County, 22 in Feidong County, 29 in Feixi County, 42 in Lujiang County, and 29 in Chaohu City (Hefei gov, 2020).

I planned to sample 4 urban schools and 2 rural schools to reflect the level of urbanization and the distribution of secondary schools in different districts and counties in Hefei. Initially I had planned to conduct random sampling of schools, stratified by urban/rural areas. However, with the ongoing Covid-19 pandemic, some secondary schools restricted their contact with external visitors, therefore random sampling was not feasible. Instead, I purposively sampled schools, only including those who were accepting external visitors. I selected four urban schools from the main urban area. Hefei Education Bureau lists different schools in different districts and does not distinguish between urban or rural areas. Therefore, for the selection of the two rural schools I first ensured that the schools are situated in the counties rather than the city, and then identified that they belonged to a rural area rather than a town. In addition to sampling rural and urban schools, I selected schools that would

represent populations that have varying income levels (according to the various GDP levels in different districts in Hefei). Urban schools are divided into public schools / private schools and boarding schools / non-boarding schools, therefore, I planned to represent these characteristics within my sample. There are no private schools in rural areas, and the majority of schools are boarding schools.

Following the development of my purposeful sampling strategy, I contacted eligible schools and six schools agreed to take part in the study. The schools were from three urban districts and one county. The four urban schools were located in 3 urban districts (Shushan district, Luyang district and Yaohai district) and comprised a public non-boarding school, a public boarding school, a private non-boarding school and a private boarding school. The two selected rural schools were located in two different villages in Feixi county and were public boarding schools.

2.2.2   Ethics

This study was approved by the University of Birmingham Science, Technology, Engineering and Mathematics Ethics committee at the University of Birmingham (ERN:20-0583) on 10th December 2020.

2.2.3   Participant recruitment

Within each of the six schools, a detailed introduction to the study was presented to the school leaders. Almost all of the students in selected schools between the age of 12 and 15 years were invited to participate in the study. In the majority of participating

schools (5 out of 6), at the request of the school leaders, students in the ninth grade (last year in the secondary school) were not included, due to teaching and timetabling constraints. Information sheets and consent forms were distributed to parents. Parental consent was passive, but they were given the option to opt their child out of the study. No parent took this option. Information sheets were also distributed to school students. On data collection day, researchers explained the study and procedures to all the students as a group and then distributed assent forms.

2.2.4   Pilot study

Before the data collection was undertaken in the six participating schools, piloting of the online survey was conducted in a different school with 177 adolescents (age 12-14). Based on this piloting, some questions which were not understood by adolescents were rephased and the survey refined. Furthermore, based on feedback, an instructional video was recorded to guide survey completion for the main data collection period.

2.2.5   Survey administration

The survey was administered online using REDCap (a secure web application for administering and managing online surveys that is approved by the University of Birmingham). Participants were given time within school and access to a computer to complete the survey. A guidance video on how to use REDCap was sent to the teachers in advance, and was shown to the students to support completion of the survey.

2.2.6   Survey measures

The survey included questions related to sociodemographic information, including age, gender and grade, and educational level of parents (as a measure of socioeconomic position). The remainder of the questionnaire included questions that were mainly derived from the literature and a variety of validated scales and instruments. These were used to assess screen and social media use and health measures, and are further detailed below. A table to illustrate the value range of these scales, the scoring interpretation and the cut-off is shown in Appendix 1. The entire questionnaire as used, is shown in Appendix 2. Where possible, questionnaires that had a Chinese version were used. However, where no translation was available, I translated the questionnaires and these was checked independently by another researcher who is fluent in both Chinese and English.

2.2.6.1   Screen, devices and social media use parameters

The questionnaire included questions on daily total screen time, daily mobile phone use time, and daily social media usage time on weekdays and weekends. Participants were asked to report total daily time in hours and minutes. The current literature suggests less than 2 hours of screen time or social media time could be beneficial and more than 2 hours could be detrimental to well-being and mental health (Hoare et al., 2016; Przybylski and Weinstein, 2017b; Twenge et al., 2018a). Therefore, I categorised responses to the questions to be able to separate the participants on the basis of this time cut-off. The responses for screen time, mobile phone usage time, and social media usage time on weekdays and weekends were divided into 4 categories: 0 hours, 0-1 hour, 1-2 hours, and > 2 hours. Average screen time, mobile

phone usage time, and social media usage time per day across the whole week were calculated from weekday and weekend responses using a weighted average. These variables were then also divided into 4 categories (0 hours, 0-1 hour, 1-2 hours, and > 2 hours). Adolescents were also asked to report the average daily screen time that was recorded on their mobile phones in the previous week. The frequency of social media checks and posts was also asked in the survey. For these two variables, responses were divided into 4 categories: never, monthly, weekly, and almost every day. The number of electronic devices accessed, average daily screen time recorded on mobile phones, and most likely time of social media use were also asked in the questionnaire on weekdays and weekends respectively.

2.2.6.2   Mental health parameters

Measures of mental wellbeing, and symptoms of depression and anxiety were assessed in the survey. For mental wellbeing, the Short Warwick-Edinburgh Mental Wellbeing Scale (SWEMWBS) was used. SWEMWBS is a 7-item scale that was developed to allow the monitoring of mental wellbeing in the general population. It has been validated for use in populations aged 12 years and older (Stewart-Brown and Platt, 2007). The scores of SWEMWBS were divided into probable depression, possible depression, average mental wellbeing, and high mental wellbeing. The Generalized Anxiety Disorder 7 items (GAD-7) questionnaire (Spitzer et al., 2007) is a measure of symptoms of anxiety and has been validated for use in adolescents (Mossman et al. (2017). The GAD-7 can differentiate between minimal anxiety, mild anxiety, moderate anxiety, and severe anxiety according to the different scores. The Kutcher Adolescent Depression Scale (KADS) (Brooks et al., 2003) was used to assess depressive symptoms. The KADS was designed to aid identification of

depressed adolescents and for monitoring symptom severity (LeBlanc et al., 2002). There are three versions of the KADS, the short 6-item version was used for this study. The six-item KADS was developed by LeBlanc et al. (2002), and has been validated for use in adolescents aged from 12 to 18 years (Brooks et al., 2003). KADS response scores are divided into two categories: no depressive symptoms and possible depressive symptoms. The SWEMWBS and KADS have Chinese versions (Mental health literacy, 2014; Ng et al., 2014), which were used in this study. I translated the GAD-7 from English to Chinese.

2.2.6.3 Sleep parameters

Two questions were included to measure sleep duration: 'What time do you go to bed on school days and weekends?' and 'What time do you get out of bed on school days and weekends?'. Then the duration of sleep in hours on school days and weekends was calculated. The Adolescent Sleep Hygiene Scale (ASHS) is a self-report questionnaire designed to assess theoretically based physiological sleep health domains that are thought to influence the quality and quantity of sleep in adolescents aged ≥12 years (LeBourgeois et al., 2005). The scale measures different factors of sleep hygiene, such as psychological, behavioral arousal, cognitive emotional, sleep environment, sleep stability, daytime sleepiness, substances (e.g. tobacco and beer), and bedtime routine. For this study, I included the Behavioral arousal and cognitive-emotional subscales. The behavioral arousal subscale included items related to screen-based devices (e.g.playing video games, watching TV, and talking on the telephone) and the cognitive-emotional subscale concentrates on thoughts in adolescents' minds before sleep. Therefore, both subscales are relevant to the aims of this study. I also included the daytime sleepiness subscale which may be relevant

to screen and social media use. For each item in the subscales the response options are scored as: never (6 points), once in a while (5 points), sometimes (4 points), quite often (3 points), frequently (2 points), always (1 point). For each subscale, the scores for each item were summed. The behavioural arousal and cognitive emotional subscales were combined as an index of sleep quality. A higher score indicated higher sleep quality. The daytime sleepiness subscale score was used separately, with a lower score indicating a higher level of daytime sleepiness. I translated the ASHS from English to Chinese. Participants were also asked about sleep latency and the times of they woke up per night.

2.2.6.4   Physical activity (PA) parameters

Overall physical activity was measured using a question from the Youth Risk Behaviour Survey (YRBS) (CDC, 2018) to measure the number of days adolescents are physically active for at least 60 minutes: 'During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?'. Response options were 0, 1, 2, 3, 4, 5, 6 or 7 days. The Godin Leisure-Time Exercise Scale (Godin, 2011) was used to measure weekly leisure time activity. This consists of the question: 'During a typical 7-Day period (a week), how many times on average do you do the following kinds of exercise for more than 15 minutes during your free time: strenuous exercise (heart beats rapidly); moderate exercise (not exhausting); and mild/light exercise (minimal effort)'. The Godin Leisure-Time Exercise Scale responses were used to calculate a weekly leisure activity score: (9 × strenuous) + (5 × moderate) + (3 × light). Scores of 24 or over, 14 to 23, and less than 14 indicate active, moderately active and indicate sedentary leisure time activity, respectively. In a review by Chinapaw et al. (2010), which summarized physical activity measurements

used in youth, both questionnaires used in this study have been evaluated as suitable questionnaires for adolescents over 12 years old. I translated both questionaries from English to Chinese. In the questionnaire, participants were also asked to report their average daily steps recorded on the Sports function of the WeChat app on their smartphones.

2.2.6.5   Other measures

In addition to the measures described above and the sociodemographic information collected, other relevant variables (identified from the literature as being associated with screen and social media use) were also collected. Self-esteem was measured using the ten-item Rosenberg Self-esteem Scale (RSES) (Rosenberg, 1965), which has been shown to be a reliable and valid quantitative tool for self-esteem assessment in adolescents (Blascovich et al., 1991). Each item is assessed on a four-point Likert scale ranging from 0 (totally disagree) to 3 (totally agree). Item scores were averaged to create a single measure of self-esteem for each participant. Social comparison when using social media was meausured using the Social Comparison Rating Scale (SCR）(Allan et al., 1995), adapted to ask about social comparison on social media.

This self-report measure consists of 11 items containing bipolar constructs. Questions are constructed in the following way: "When I compare myself to others on social media, I feel...". Participants were asked to choose a number from 1 to 10 that expressed where they would position themselves between two poles. Items were summed to produce a total score with higher values indicating more positive self-perceptions compared with others.

Motives for using social media were measured using the Facebook Motives Questionnaire (Marino et al., 2016b), adapted to encompass all social media. There are four dimensions within the measure: coping (e.g. "To forget your worries?"); conformity (e.g. "To be liked by others?"); enhancement (e.g. "Because it is exciting?"); and social motive (e.g. "To come into contact with others?"). Each dimension consists of 4 items, rated on a 5-point scale (from (1) "never or almost never" to (5) "always or almost always"). Scores for each dimension range from 4 to 20, with higher scores indicating a higher level of each motive. Problematic social media use (PSMU) was measured using the problematic Facebook use (PFU) scale developed and validated by Marino et al. (2016b), again adapted for social media. There is evidence to support that the PFU provides a theory-driven tool to assess the problematic use of Facebook among male and female adolescents (Marino et al., 2016a). The PSMU scale consisted of fifteen items and participants were asked to rate the extent to which they agreed with each of the items. Scores for each item were summed to give a total PSMU score ranging from 15 to 120, with higher scores indicating a higher level of PSMU. The RSES has a Chinese version (Chen et al., 2015). I translated the SCR and PSMU from English to Chinese.

2.2.7   Data cleaning

REDCap records every survey entry, even if it is entirely blank. In addition, if the same person goes into the survey more than once, multiple records are recorded. First, I excluded the records where full consent was not given and records where consent was given but all other variables were blank (n=466). Next, I excluded records where the respondents who only answered a few questions, which resulted in almost no meaningful information provided, or had chosen the same answer choice for all

questions on the survey (e.g., the first answer option) (n=151). Next, I identified

multiple records for individual students by matching name, grade, class and date of

birth. Where data were duplicated in full for the same student the first record was

retained, and the second record deleted. Where data were incomplete across multiple

records for the same student, records were combined into a more completed record.

Where there were multiple responses from one student to a data item across multiple

records, the response from the most complete record was retained. Implausible values

were dealt with by cross-checking or through setting of boundaries based on known

factors (e.g. student schedules based on school time). I also imputed missing

information on grade from their answers about which class they are from. The

summary of data cleaning procedures is shown in Figure 2.

Figure 2 Flow chart of data cleaning
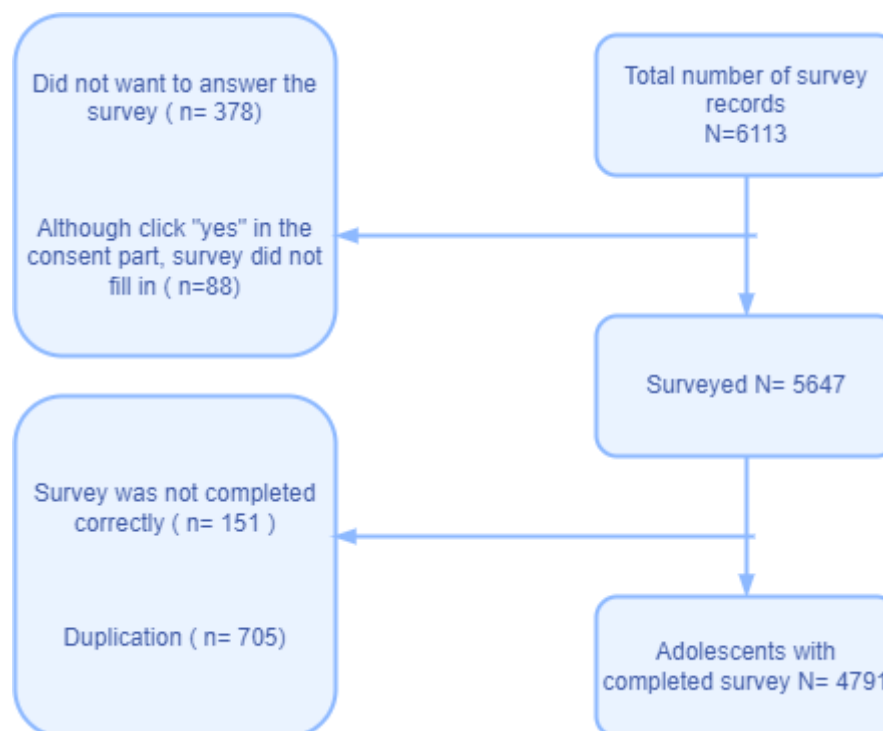
2.2.8　Data analysis

Statistical analyses were performed using STATA16.0.

2.2.8.1　Descriptive analysis and comparison across gender and age groups

Descriptive analyses of sociodemographic characteristics and measures of screen time, phone and social use, and mental health/wellbeing measures, sleep and physical activity were undertaken. Data were summarised for the total study sample, and then separately for boys and girls, and different age groups (12-13 years and 14-15 years). Means and standard deviations (SD) were used to summarise normally distributed variables. Medians and interquartile ranges (IQR) were used for skewed distribution variables. Categorical variables were summarised as number (n) and percentage (%). T-tests and Mann-Whitney U-tests were used to compare continuous variables across gender and age groups, depending on the distribution of the data. Chi-square tests were used to compare categorical data across gender and age groups. P values of less than 0.05 were considered statistically significant. Analyses are presented in Chapter 3, section A.

2.2.8.2　Exploration of associations between screen and social media use, and wellbeing, mental health, sleep and physical activity

To explore the relationships between screen time, electronic devices, and social media use, with related health outcomes, regression analysis was used. Linear regression was used to explore the potential associations when the dependent variables were continuous (self-esteem, mental wellbeing, sleep duration, sleep quality and daytime sleepiness), logistic regression was undertaken for the binary dependent variables

(depressive symptoms, anxiety, leisure time activity intensity), and Poisson regression was used to explore the potential associations when the dependent variables were count variables (number of days of 60+ minutes of physical activity). Regression models were developed first including only the explanatory variable of interest and the outcome variable, and then the models were developed by introducing the covariates of age, gender, and education level of parents, the school ID, and boarding school status (boarding and non-boarding; to account for the extended restrictions regarding screen use for boarding school pupils). School ID was included as a covariate in the model to account for the clustering of factors that may occur within schools. Boarding /non-boarding school status was included as covariate, because there may be differences in the explanatory and outcome variables that are related to whether or not the participant attends a boarding school (i.e., screen time, electronic devices use, social media time, mental wellbeing, sleep and physical activity). Regression coefficients, odds ratios and incidence rate ratios for the explanatory variables of interest are presented with 95% confidence intervals and p values in results. As a key focus of this thesis is on the relationship between social media and physical activity, interaction terms for gender and social media use, and age and social media use were introduced into the models as additional covariates to explore potential subgroup differences in the associations between social media use and physical activity. Analyses are presented in Chapter 3, section B.

2.2.8.3   Exploration of interrelationships between social media use, health related outcomes and potential mediating factors

To explore the association between social media use and physical activity further, mediation analysis was conducted using generalised structural equation modelling (GSEM) in STATA16.0. This was used to test whether depressive symptoms, sleep duration, and social comparison, could be potential mediators in the association between social media usage and physical activity. Further details on the model development and outputs are given in Chapter 3, section C. Modelling coefficients are presented with 95% confidence intervals and p values in the results.

CHAPTER 3 RESULTS OF QUANTITATIVE STUDY

3.1 Section A. Social media use, mental wellbeing, sleep and physical activity: descriptive results

3.1.1 Participant sample

Of 6250 students invited, 4791 from six secondary schools consented to participate (response rate = 76.66%). There were 2469 (51.53%) boys and 2113 (44.10%) girls, with 175 participants preferring not to disclose their gender (3.65%) and 34 participants choosing other as their gender (0.71%). Participants were mainly younger, with 2891 (60.34%) in 7th grade, 1799 (37.55%) in 8th grade, and 101 (2.11%) in 9th grade. The normal age for students in the 7th and 8th grades is 12-13 years old, and for students in the 8th and 9th grades is 14-15 years old. The majority of participants' parents had an educational level lower than undergraduate (63.54%). Most participants were from urban private schools (n=2284, 47.67%) or urban public schools (n=1959, 40.89%). Only 548 participants (11.44%) were from schools in rural areas (Table 1).

Table 1 participant characteristics

		N (%) or Mean (SD) / Median (IQR)				
		Total Sample	**Gender**		**Age**	
			Boys	**Girls**	**12-13 years**	**14-15 years**
		4,791 (100%)	2496 (51.53%)	2,113 (44.10%)	2,877 (60.05%)	1,914 (39.95%)
Age (years) mean (SD)		13.34 (0.87)	13.39 (0.88)	13.29 (0.86)	12.74 (0.46)	14.25 (0.48)
Gender n (%)	Boys	2,469 (51.53)	N/A	N/A	1,409 (48.97)	1,060 (55.38)
	Girls	2,113 (44.11)			1,342 (46.65)	771 (40.28)
	Other	175 (3.65)			106 (3.68)	69 (3.61)
	Missing	34 (0.71)			20 (0.70)	14 (0.73)
Grade n (%)	7th	2,891 (60.34)	1,498 (60.67)	1,282 (60.67)	2,371 (82.41)	520 (27.17)
	8th	1,799 (37.55)	935 (37.87)	773 (36.58)	504 (17.52)	1,295 (67.66)
	9th	101 (2.11)	36 (1.46)	58 (2.74)	2 (0.07)	99 (5.17)
Education level of father n (%)	Below undergraduate	3,044 (63.54)	1,614 (65.37)	1,332 (63.04)	1,744 (60.62)	1,300 (67.92)
	Undergraduate	1,481 (30.91)	722 (29.24)	672 (31.80)	956 (33.23)	525 (27.43)
	Postgraduate and above	261 (5.45)	131 (5.31)	107 (5.06)	174 (6.05)	87 (4.55)
	Missing	5 (0.1)	2 (0.08)	2 (0.09)	3 (0.10)	2 (0.10)
Education level of mother n (%)	Under undergraduate	3,284 (68.55)	1,726 (69.91)	1,437 (68.01)	1,900 (66.04)	1,384 (72.31)
	Undergraduate	1,304 (27.22)	639 (25.88)	597 (28.25)	840 (29.20)	464 (24.24)
	Postgraduate and above	198 (4.13)	102 (4.13)	77 (3.64)	134 (4.66)	64 (3.34)
	Missing	5 (0.1%)	2 (0.08)	2 (0.09)	3 (0.10)	2 (0.10)
School type* n (%)	Rural Public	548 (11.44)	254 (10.29)	283 (13.39)	293 (10.18)	255 (13.32)
	Urban Public	1,959 (40.89)	938 (37.99)	929 (43.97)	1,226 (42.61)	733 (38.30)
	Urban Private	2,284 (47.67)	1,277 (51.72)	901 (42.64)	1,358 (47.20)	926 (48.38)

*Public secondary schools are secondary schools organised by national government departments and are basically funded by government grants; private secondary schools are secondary schools that are not assisted by national education funds,

so they will charge tuition fees to maintain their operation. Due to the nature of private schools, there are almost no private schools in rural areas

3.1.2 Screen time, electronic device use and social media use in participants

Table 2 presents data on screen, device, and social media use in participants overall, and by gender and age groups. There was a large difference in screen time use between weekdays and weekends. On weekdays, almost half of the students (n=2124, 44.33%) reported no screen time, but only 798 (16.66%) reported no screen time on weekends. Overall screen time was higher on weekend days compared with weekdays; for example, 40.9% of adolescents in the sample reported 1-2 hours of screen time per day on weekends, compared with 21.0% on weekdays, whilst 26.6% reported over 2 hours per day on weekends, compared with 6.3% on weekdays. There were significant differences in screen time across gender and age groups on weekdays and weekends. A higher proportion (7.73% and 30.51%) of older adolescents (14–15-years old) used screens for more than 2 hours per day on weekdays and weekends, than those aged 12-13 (5.28% and 24.05%, p for trend = 0.00001 on weekdays and weekends). Girls had significantly higher screen time on weekends (p for trend= 0.03).

The majority (n=2521; 52.62%) of adolescents reported daily screen time use of <1 hour, averaged over the whole week. However, 10% reported no screen use, whilst a quarter (n=1181; 24.65%) reported 1-2 hours and the remainder (n=608; 12.69%) reported over 2 hours, averaged over the whole week. There was a significant difference in average daily screen time across gender groups (p=0.004), but no clear trend. Regarding age groups, there was a more pronounced difference, with adolescents aged 14-15 having a higher average daily screen time compared with adolescents aged 12-13 (chi-squared for trend p = 0.00001).

Overall, mobile phone use is lower than screen time use on weekdays and weekends, but the pattern of usage is similar to that reported for screen use. On weekdays, 55.56% of adolescents in the sample (n=2662) did not spend any time using mobile phones, and 2.53% (n=121) reported more than two hours of usage. At weekends, participants reported higher usage time, with 23.34% reporting no mobile phone time, and 15.8% reporting more than 2 hours on mobile phones per day. Only 6% of participants reported over 2 hours of average daily mobile phone time across the whole week. Overall, girls compared to boys, and older compared to younger adolescents, had higher mobile phone use. This trend was verified using the objective mobile phone use data, with significant chi-squared for trend tests for both gender and age (chi-squared for trend p-value for gender = 0.0050 and for age <0.00001) (Table 2).

In terms of the number of electronic devices accessed, most adolescents (72.26%) reported using either no or one device on weekdays, but on weekends 80.86% of adolescents reported using 2 or more devices. This trend was seen across gender and age groups, although there were some marginal differences across both gender and age groups, with boys (compared with girls) and the older age group (compared with the younger age group) more likely to report using 4 or more devices (Table 2).

Regarding time spent using social media, the same trend as screen time and mobile phone time was observed. Overall, 58.32% participants (n= 2794) did not use social media on weekdays. Girls reported more social media time than boys (p value for trend=0.01), and adolescents aged 14-15 reported more social media time than those aged 12-13 (p value for trend = 0.00001) on weekdays. On weekends, the proportion

of participants reporting no social media use decreased to 22.42% (n=1074). 26.78% of adolescents in the sample used social media for 0-1 hours per day and (38.91% used social media for between 1-2 hours per day at weekends. There were differences in social media usage time between genders (chi-squared p-value for trend=0.0002) and age (chi-squared p-value for trend=0.00001) on weekends. Regarding average social media time per day across the whole week, 57.02% (n=2732) of participants reported using social media for 0-1 hours, 17.24% (n=826) reported using social media for 1-2 hours and 3.94% (n=189) reported over two hours of use. There were significant differences between gender (chi-squared p-value for trend = 0.003) and age groups (chi-squared p-value for trend = 0.00001) in average social media time per day across the whole week (Table 2).

In response to the questions about the most likely time of day for social media use, on weekdays, the most likely time of use was after-school and later in the evening. Daytime use was the most likely time of social media use on weekends, reported by 38.03%. Compared with boys, girls reported higher social media usage in the daytime, early evening, and before sleep on weekends. Also, older adolescents reported higher social media usage in the daytime and early evening on weekends compared with younger adolescents. Differences in the most likely time of social media use on weekdays were observed across age groups with more older adolescents using social media after school and before sleep.

The number of times that adolescents viewed their social media per day was relatively low, with around 30% never or rarely checking their accounts and only 13% of participants checking their accounts almost every day. Regarding the frequency of posting on social media, around 50% of participants never or rarely posted, whereas 42% posted on social media weekly. Older adolescents checked social media more frequently than the 12-13 year age group (p for trend < 0.00001), but there were no gender differences in checking frequency. Conversely, girls had a significantly higher frequency of social media posting than boys (p for trend < 0.00001), but there were no differences between age groups (Table 2).

Regarding motivations for social media use, scores for coping and enhancement were higher (median = 9, IQR: 7-12) than scores for conformity (median = 7; IQR: 4-10) and social (median = 8; IQR: 6-12) respectively. There were differences in the motivations of enhancement and social across age groups and gender groups, with boys and 14-15 years old adolescents reporting higher levels of motivation. The median score for Problematic Social Media Use (PSMU) was 41 (IQR: 24-59) for all participants. There was a significant difference in age for PSMU with adolescents aged 14–15-years reporting a higher median score than the 12–13-year age group (p=0.0001). Also, there was a significant difference in PSMU across gender groups with girls having higher PSMU scores (p=0.04) (Table 2).

Table 2 Screen time, electronic device use and social media use in participants

		N (%) or Mean (SD) / Median (IQR)						
			Gender				Age	
		Total (4,791, 100%)	Boys (2496; 51.53%)	Girls (2,113; 44.10%)	p value for gender	12-13 years (2,877; 60.05%)	14-15 years (1,914; 39.95%)	p value for age
Screen time and electronic devices use								
Total screen time per day - weekdays (hours) n (%)	0h	2,124 (44.33)	1,124 (45.52)	911 (43.11)	0.007 p for trend: 0.88	1,339 (46.54)	785 (41.01)	0.0001 p for trend: 0.00001
	0-1h	1,358 (28.34)	651 (26.37)	652 (30.86)		797 (27.70)	561 (29.31)	
	1-2h	1,007 (21.02)	541 (21.91)	417 (19.73)		587 (20.40)	420 (21.94)	
	> 2h	300 (6.26)	152 (6.16)	132 (6.25)		152 (5.28)	148 (7.73)	
Total screen time per day - weekends (hours) n (%)	0h	798 (16.66)	451 (18.27)	306 (14.48)	0.0002 p for trend: 0.03	540 (18.77)	258 (13.48)	< 0.00001 p for trend: 0.00001
	0-1h	758 (15.82)	354 (14.34)	372 (17.61)		465 (16.16)	293 (15.31)	
	1-2h	1,958 (40.87)	1,035 (41.92)	852 (40.32)		1,179 (40.98)	779 (40.70)	
	> 2h	1,276 (26.63)	628 (25.44)	583 (27.59)		692 (24.05)	584 (30.51)	
Average screen time per day across the whole week (hours) n (%)	0h	479 (10.00)	273 (11.06)	177 (8.38)	0.004 p for trend: 0.79	331 (11.51)	148 (7.73)	< 0.00001 p for trend: 0.00001
	0-1h	2,521 (52.62)	1,257 (50.91)	1,169 (55.32)		1,537 (53.42)	984 (51.41)	
	1-2h	1,181 (24.65)	625 (25.31)	504 (23.85)		677 (23.53)	504 (26.33)	
	> 2h	608 (12.69)	313 (12.68)	262 (12.40)		330 (11.47)	278 (14.52)	
Daily mobile phone usage time (weekdays) (hours) n (%)	0h	2,662 (55.56)	1,420 (57.51)	1,126 (53.29)	< 0.00001 p for trend: 0.19	1,681 (58.43)	981 (51.25)	< 0.00001 p for trend: 0.00001
	0-1h	1,303 (27.20)	609 (24.67)	645 (30.53)		746 (25.93)	557 (29.10)	
	1-2h	704 (14.690	386 (15.63)	286 (13.54)		387 (13.45)	317 (16.56)	
	> 2h	121 (2.53)	53 (2.15)	56 (2.65)		63 (2.19)	58 (3.03)	
Daily mobile phone usage time (weekends) (hours) n (%)	0h	1,118 (23.34)	624 (25.27)	440 (20.82)	< 0.00001 p for trend: 0.63	721 (25.06)	397 (20.74)	< 0.00001 p for trend: 0.00001
	0-1h	1,025 (21.39)	459 (18.59)	532 (25.18)		645 (22.42)	380 (19.85)	
	1-2h	1,888 (39.41)	985 (39.89)	816 (38.62)		1,111 (8.62)	777 (40.60)	
	> 2h	758 (15.82)	400 (16.20)	324 (15.33)		398 (13.83)	360 (18.81)	
Average daily mobile phone usage time	0h	1,038 (21.67)	578 (23.41)	407 (19.26)	0.002 p for trend: 0.13	675 (23.46)	363 (18.97)	0.0001 p for trend: <0.00001
	0-1h	2,668 (55.69)	1,325 (53.67)	1,240 (58.68)		1,602 (55.68)	1,066 (55.69)	
	1-2h	796 (16.61)	424 (17.17)	342 (16.19)		448 (15.57)	348 (18.18)	

across the whole week (hours) n (%)	> 2h	286 (5.97)	140 (5.67)	123 (5.82)		150 (5.21)	136 (7.11)	
Number of electronic devices accessed on weekdays n (%)	0 device	2,006 (41.87)	1,036 (41.96)	877 (41.50)	< 0.0001	1,278 (44.42)	728 (38.04)	< 0.0001
	1 device	1,456 (30.39)	722 (29.24)	671 (31.76)		843 (29.30)	613 (32.03)	
	2 devices	693 (14.46)	343 (13.89)	328 (15.52)		408 (14.18)	285 (14.89)	
	3 devices	292 (6.09)	153 (6.20)	127 (6.01)		166 (5.77)	126 (6.58)	
	≥ 4 devices	344 (7.18)	215 (8.71)	110 (5.2)		182 (6.33)	162 (8.64)	
Number of electronic devices accessed on weekend n (%)	0 device	515 (10.75)	296 (11.99)	186 (8.80)	< 0.0001	337 (11.71)	178 (9.30)	< 0.0001
	1 device	402 (8.39)	214 (8.67)	172 (8.14)		260 (9.04)	142 (7.42)	
	2 devices	949 (19.81)	454 (18.39)	445 (21.06)		542 (18.84)	407 (21.26)	
	3 devices	1,637 (34.17)	788 (31.92)	790 (37.39)		994 (34.55)	643 (33.59)	
	≥4 devices	1288 (26.88)	717 (29.03)	520 (24.61)		744 (25.86)	544 (28.43)	
Average daily screen time recorded on mobile phone in the previous week (hours) median (IQR)	0h	828 (17.28)	475 (19.24)	308 (14.58)	<0.00001 p for trend: 0.005	556 (19.33)	272 (14.21)	0.0001 p for trend: <0.00001
	0-1h	859 (17.93)	396 (16.04)	421 (19.92)		537 (18.67)	322 (16.82)	
	1-2h	1,664 (34.73)	893 (36.17)	710 (33.60)		999 (34.72)	665 (34.74)	
	> 2h	1,27 (26.61)	625 (25.31)	602 (28.49)		698 (24.26)	577 (30.15)	
Social media use								
Total social media time per day - weekdays (hours) n (%)	0h	2,794 (58.32)	1,502 (60.83)	1,174 (55.56)	0.003 p for trend: 0.01	1,746 (60.69)	1,048 (54.75)	0.0001 p for trend: 0.00001
	0-1h	1,274 (26.59)	608 (24.63)	612 (28.96)		745 (25.90)	529 (27.64)	
	1-2h	646 (13.48)	321 (13.00)	293 (13.87)		346 (12.03)	300 (15.67)	
	> 2h	71 (1.48)	35 (1.42)	31 (1.47)		38 (1.32)	33 (1.72)	
Total social media time per day- weekends (hours) n (%)	0h	1,074 (22.42)	614 (24.87)	406 (19.21)	0.0001 p for trend: 0.0002	695 (24.16)	379 (19.80)	0.0004 p for trend: 0.00001
	0-1h	1,283 (26.78)	638 (5.84)	589 (27.88)		778 (27.04)	505 (26.38)	
	1-2h	1,864 (38.91)	940 (8.07)	855 (40.46)		1,094 (38.03)	770 (40.23)	
	> 2h	561 (11.71)	272 (11.02)	259 (12.26)		307 (10.67)	254 (13.27)	
Average social media time per day across the whole week (hours) n (%)	0h	1,035 (21.60)	593 (24.02)	390 (18.46)	0.0001 p for trend: 0.003	669 (23.25)	366 (19.12)	0.0001 p for trend: 0.00001
	0-1h	2,732 (57.02)	1,354 (54.84)	1,268 (60.01)		1,649 (57.32)	1,083 (56.58)	
	1-2h	826 (17.24)	429 (17.38)	365 (17.27)		455 (15.82)	371 (19.38)	
	> 2h	189 (3.94)	88 (3.56)	86 (4.07)		101 (3.51)	88 (4.60)	

Most likely time of social media use on weekdays n (%)	No social media use	2,366 (49.38)	1,275 (51.64)	991 (46.90)	0.06	1,493 (51.89)	873 (45.61)	<0.0001
	Morning before school	43 (0.90)	22 (0.89)	16 (0.76)		20 (0.70)	23 (1.20)	
	During school time	110 (2.30)	55 (2.23)	53 (2.51)		74 (2.57)	36 (1.88)	
	After school	1,189 (24.82)	595 (24.10)	543 (25.70)		676 (23.50)	513 (26.80)	
	Later in the evening, before sleep	967 (20.18)	474 (19.20)	448 (21.20)		559 (19.43)	408 (21.32)	
Most likely time of social media use on weekends n (%)	No social media use	953 (19.89)	548 (22.20)	358 (16.94)	<0.0001	629 (21.86)	324 (16.93)	<0.0001
	Morning	131 (2.73)	76 (3.08)	49 (2.32)		70 (2.43)	61 (3.19)	
	During the day	1,822 (38.03)	933 (37.79)	818 (38.71)		1,057 (36.74)	765 (39.97)	
	Early evening	1,057 (22.06)	522 (21.14)	489 (23.14)		624 (21.69)	433 (22.62)	
	Later in the evening, before sleep	782 (16.32)	370 (14.99)	376 (17.79)		477 (16.58)	305 (15.94)	
Frequency of checking/updating social media accounts n (%)	Never	1,380 (28.80)	711 (28.80)	609 (28.82)	0.63 p for trend: 0.54	891 (30.97)	489 (25.55)	0.0002 p for trend: <0.00001
	Monthly	42 (0.88)	18 (0.73)	19 (0.90)		23 (0.80)	19 (0.99)	
	Weekly	2,641 (55.12)	1,369 (55.45)	1,176 (55.66)		1,569 (54.54)	1,072 (56.01)	
	Almost everyday	633 (13.21)	334 (13.53)	259 (12.26)		347 (12.06)	286 (14.94)	
Frequency of posting on social media n (%)	Never	2,317 (48.36)	1,335 (54.07)	888 (42.03)	<0.00001 p for trend: < 0.00001	1,397 (48.56)	920 (48.07)	0.71 p for trend: 0.72
	Monthly	71 (1.48)	26 (1.05)	41 (1.94)		41 (1.43)	30 (1.57)	
	Weekly	1,992 (41.58)	923 (37.38)	987 (46.71)		1,204 (41.85)	788 (41.17)	
	Almost every day	207 (4.32)	97 (3.93)	96 (4.54)		117 (4.07)	90 (4.70)	
Motivation of Social Media Use: Coping (score range = 4-20; higher scores = higher		9 (7-12)	9 (7-12)	9 (7-12)	0.67	9 (7-12)	9 (7-12)	0.08

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motivation) median (IQR)								
Motivation of Social Media Use: Conformity (score range = 4-20; higher scores = higher motivation) median (IQR)		7 (4-10)	7 (4-10)	7 (4-10)	0.42	7 (4-10)	7 (4-10)	0.26
Motivation of Social Media Use: Enhancement (score range= 4 to 20, higher scores = higher motivation) median (IQR)		9 (7-12)	9 (7-13)	9 (7-12)	0.02	9 (7-12)	9 (7-13)	0.03
Motivation of Social Media Use: Social (score range = 4 to 20, higher scores = higher motivation) median (IQR)		8 (6-12)	9 (6-12)	8 (6-12)	0.005	8 (6-12)	9 (6-12)	0.01
Problematic Social Media Use (measured by PSMU, total score range is from 15 to 120, higher scores indicate higher level of PSMU) median (IQR)		41 (24-59)	40 (23-58)	41 (25-59)	0.04	39 (22-57)	43 (26-60)	0.0001

3.1.3 Traits of social media usage

Figures 3-8 provide a summary of the traits of social media use by adolescents in the sample, including: social media applications used; accounts followed; and the types of social media content that adolescents access and post.

Figure 3 Social media applications used by adolescents

	QQ	WeChat	Youku	Tecent Vedio	Bilibili	TikTok	Baidu Tieba	Sina Weibo
■ Total	75.93%	49.97%	6.47%	15.38%	26.88%	29.43%	7.87%	6.26%
■ Boys	76.59%	52.45%	6.68%	16.77%	29.89%	25.68%	7.05%	2.23%
■ Girls	75.53%	47.66%	6.25%	14.48%	22.15%	34.60%	9.13%	11.03%
■ 12-13 years	73.31%	50.71%	5.74%	14.91%	26.24%	29.96%	7.33%	6.22%
■ 14-15 years	79.89%	48.85%	7.58%	16.09%	27.85%	28.63%	8.67%	6.32%

■ Total ■ Boys ■ Girls ■ 12-13 years ■ 14-15 years
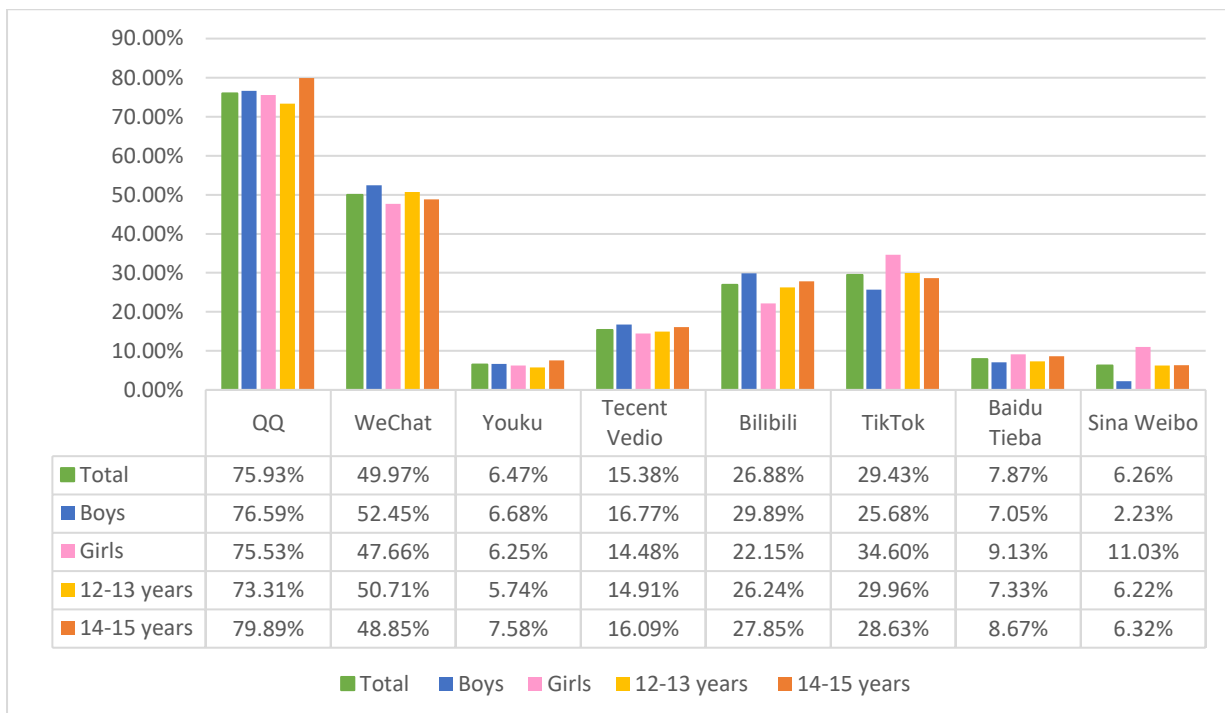
Figure 4 Social media accounts followed by adolescents

	Your friends	Similar people your age	Your family	News	Entertainment	Health	Other
■ Total	32.85%	4.82%	20.16%	4.36%	26.19%	3.69%	4.51%
■ Boys	33.94%	4.74%	20.70%	4.66%	24.30%	4.21%	4.41%
■ Girls	31.80%	4.64%	20.21%	4.02%	28.02%	3.08%	4.40%
■ 12-13 years	31.84%	4.41%	20.82%	4.52%	25.86%	4.10%	5.04%
■ 14-15 years	34.38%	5.43%	19.17%	4.13%	26.70%	3.08%	3.71%

■ Total ■ Boys ■ Girls ■ 12-13 years ■ 14-15 years
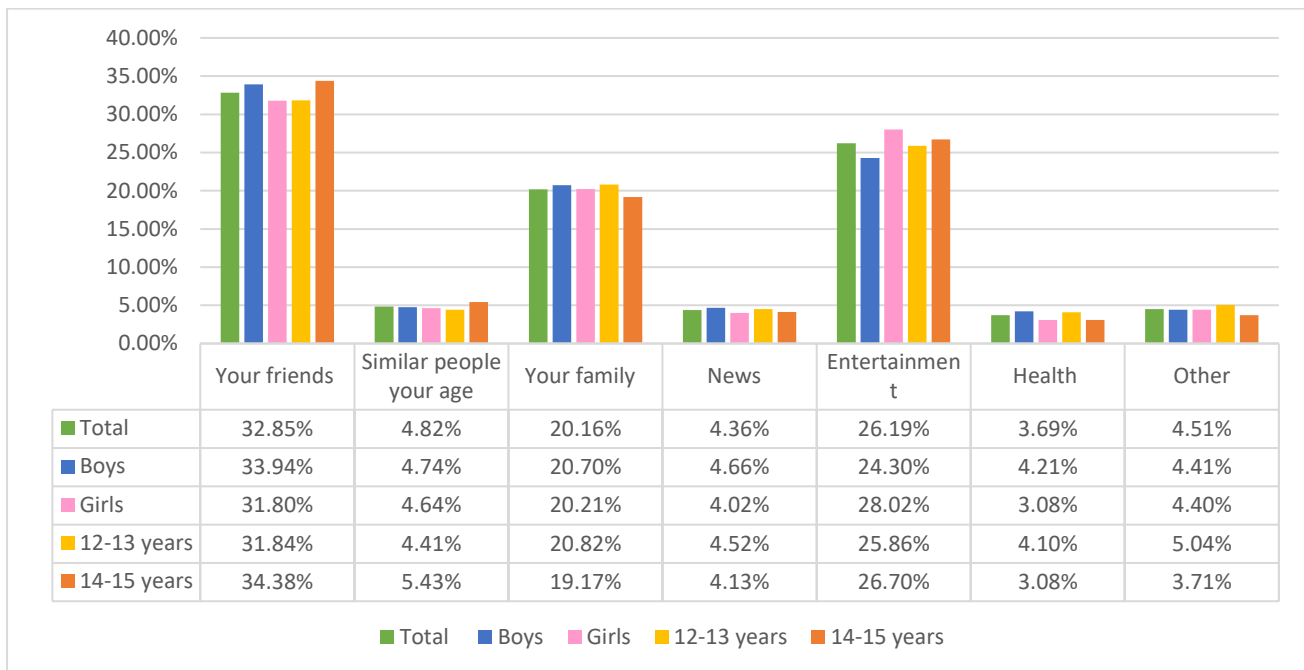
The most used social media platforms for adolescents were QQ, WeChat, and TikTok, and the main accounts followed by adolescents included friends, entertainment, and family, with little variation by age group or gender (Figure 3 and 4).

Figure 5 The types of social media content that adolescents access

	Information related to your daily activities	Information about yourself	Information related to your friends, family or pets	News information	Entertainment information	Health information	Other
Total	48.51%	23.00%	31.54%	21.71%	46.34%	21.75%	7.12%
Boys	48.48%	19.85%	29.69%	25.35%	43.01%	24.87%	6.16%
Girls	49.22%	26.93%	34.55%	17.32%	50.40%	18.55%	7.71%
12-13 years	48.52%	22.11%	30.76%	20.72%	46.16%	22.25%	7.54%
14-15 years	48.48%	24.35%	32.71%	23.20%	46.60%	21.00%	6.48%
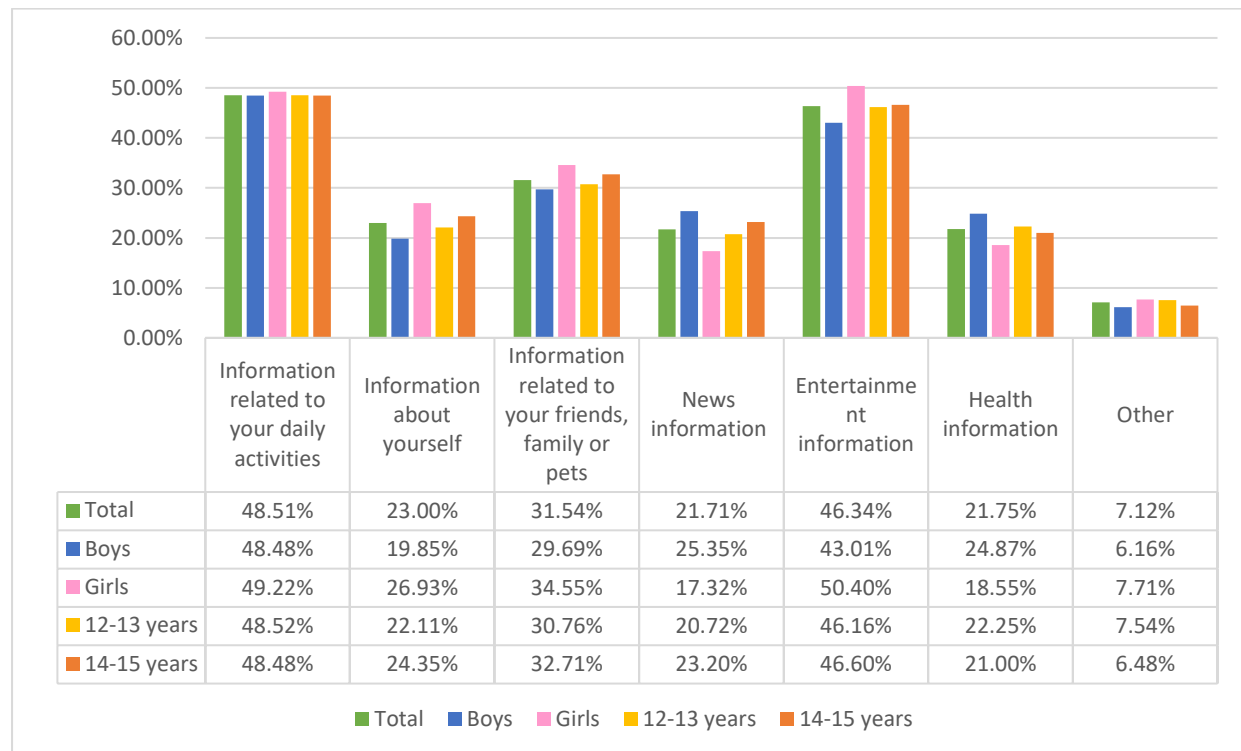
Figure 6 The types of social media content that adolescents post

	Information related to your daily activities	Information about yourself	Information related to your friends, family or pets	News information	Entertainment information	Health information	N/A	Other
Total	45.71%	24.63%	19.43%	8.68%	33.46%	12.98%	28.95%	4.68%
Boys	41.35%	19.44%	17.82%	10.81%	30.78%	15.76%	34.06%	3.77%
Girls	51.68%	31.09%	21.72%	6.11%	36.91%	9.89%	23.42%	5.16%
12-13 years	45.60%	23.15%	18.73%	8.41%	33.47%	13.49%	29.30%	4.83%
14-15 years	45.87%	26.85%	20.48%	9.09%	33.44%	12.23%	28.42%	4.44%

N/A refers to they do not post any type of posting or do not use social media

The types of social media content most often accessed related to entertainment information; and interactions with friends and family. Girls were more likely to access entertainment information, information about themselves, and information related to friends, family, or pets than boys. Boys were more likely to access news information and health-related information than girls (Figure 5).

The type of social media content posted was information related to entertainment and friends and family or pets. Girls posted more information about themselves, daily activities, entertainment and their family and friends, compared with boys (Figure 6).

Figure 7 The format of adolescents' posts to social media

	Stories	Images	Videos	Text	Memes	N/A	Other
Total	18.01%	41.06%	23.50%	37.36%	24.98%	29.70%	3.36%
Boys	18.87%	33.29%	25.88%	27.83%	23.57%	34.63%	3.16%
Girls	17.51%	50.35%	20.92%	48.98%	27.31%	23.99%	3.08%
12-13 years	18.25%	40.42%	22.35%	36.91%	25.55%	29.89%	3.44%
14-15 years	17.66%	42.01%	25.24%	38.04%	24.14%	29.41%	3.24%
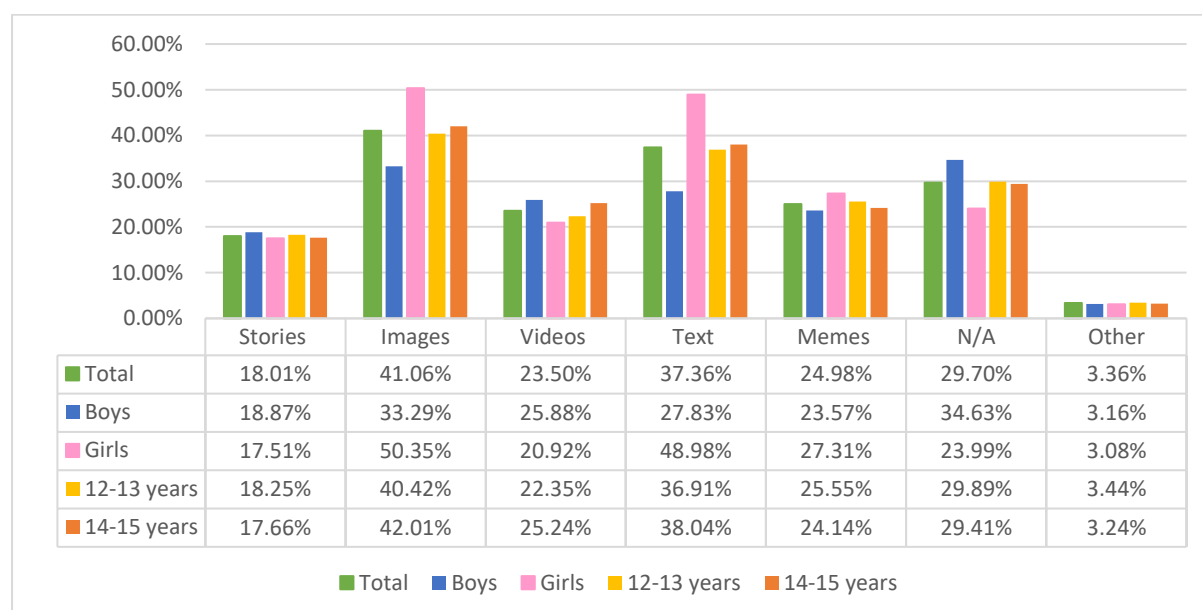
N/A refers to they do not post any posting or do not use social media

Figure 8 The reasons for using social media among adolescents

	To share my daily activities	To share information about me	To talk to and check in with my friends and family	To access information related to entertainment	To access health information	Others (including kill time, education/learning, watch news and just for fun)
Total	11.41%	8.14%	28.71%	29.16%	15.61%	2.20%
Boys	11.87%	9.36%	30.21%	28.68%	18.31%	1.86%
Girls	11.12%	6.77%	27.21%	30.00%	12.68%	2.41%
12-13 years	10.96%	7.89%	27.80%	27.77%	15.16%	2.29%
14-15 years	12.12%	8.46%	30.04%	31.25%	16.31%	2.00%

The most frequent formats of posts shared by adolescents on social media were images and texts (Figure 7). The main reasons for using social media were talking to and checking in with friends and family and accessing information related to entertainment. There were only marginal differences between gender and age groups (Figure 8).

3.1.4 Mental wellbeing, sleep and physical activity in participants

Table 3 presents data related to mental wellbeing, sleep and physical activity in the whole study sample and by age and gender. Overall, 40.10% of participants (n=1921) reported low self-esteem and 9.58% (n=459) reported high self-esteem. There were differences in self-esteem across gender and age groups, with girls and the older age group less likely to report high self-esteem than boys and the younger age group,

respectively, and there was a significant trend of lower self-esteem in the older, compared with the younger age group (chi-squared for trend p value = 0.02).

Regarding mental wellbeing measured by SWEMWBS, 937 participants (19.56%) reported probable and 517 participants (10.79%) possible depression. These percentages were higher in girls (probable depression: n=453; 21.44% and possible depression: n=253; 11.97%) and adolescents aged 14-15 years (probable depression: n=416; 21.73% and possible depression: n=212; 11.08%). There were significant differences between the gender and age groups, with boys and the 12–13-year-old groups having higher wellbeing (chi-squared for trend p value <0.00001 for both gender and age comparisons) (Table 3). The proportion of adolescents with severe anxiety was relatively low (9.27%; n=444). This proportion was similar across age groups but higher in girls (n=247, 11.69%). There were differences in anxiety levels across age and gender groups, with boys and adolescents aged 12-13-years reporting mild anxiety symptoms (chi-squared for trend p-value <0.00001 for both gender and age). There were 30.93% participants (n=1428) who reported possible depressive symptoms, with more girls (n=691; 32.70%) and 14-15 year-old adolescents (n=648; 33.86%) reporting possible depressive symptoms, compared with boys and 12-13 years old adolescents (Table 3). Overall, the median score for the social comparison scale was 57 (IQR: 53-77). Compared with girls (median: 56, IQR: 51-75), boys (median:59, IQR: 54-81) were more likely to positively compare themselves with others while using social media. Adolescents aged 12-13 (median: 58, IQR: 54-80) were more likely to compare themselves positively to their peers compared with adolescents aged 14-15 (median: 56, IQR: 51-75) (Table 3).

The average sleep duration for participants was 7.70 hours (SD: 1.04) on weekdays and 9.64 hours (SD: 1.72) on weekends. The average sleep duration across the whole week was 8.25 hours (SD: 0.96). Generally, girls slept less than boys, and the older adolescents slept less than the younger adolescents, on weekdays and weekends, but the differences were only significant between age and gender groups on weekdays and across the whole week, not on weekends. The median score for sleep quality for all participants was 9.67 (IQR: 8, 10.83). There was a significant difference in sleep quality by age group with younger adolescents having slightly higher sleep quality scores. The median score of daytime sleepiness for all participants was 5.5 (IQR: 4-6). There was a significant difference in daytime sleepiness by gender group with boys having slightly lower daytime sleepiness scores. 65.31% (n=3129) of adolescents reported that they took less than 20 minutes to fall asleep (sleep latency). There was a significant difference between boys and girls, with girls reporting longer time to fall asleep (chi-squared for trend p value = 0.0023). 58.74% (n= 2814,) of adolescents experienced no interruption during sleep, with a significant difference across gender groups, with girls reporting more sleep interruption than boys (chi-squared for trend p value <0.00001) (Table 3).

Only 11.54% (n=553) of participants reported doing at least one hour of physical activity every day. This percentage was higher for boys than girls (14.05% vs. 8.38%), and there was a significant difference among gender groups, with boys reporting more days doing at least one hour of physical activity than girls (chi-squared for trend p value <0.00001). Regarding weekly leisure time activity, most participants (n=3779; 78.88%) were in the highly active category. Differences between gender and age groups in weekly leisure time activity were not significant. Regarding the number of

steps recorded by WeChat Sports, boys (median: 5000 IQR: 1502-9999) recorded more steps than girls (median: 4000, IQR: 1400-8000), and the younger group (median: 5000, IQR: 1888-8658) recorded more steps than the older group (median: 4000, IQR: 1041-8000). In all measures of physical activity, there were no significant age group differences (Table 3).

Table 3 Mental wellbeing, sleep and physical activity situation in participants

		N (%) or Mean (SD) / Median (IQR)						
			Gender			Age		
		Total (4,791; 100%)	Boys (2496; 51.53%)	Girls (2,113; 44.10%)	p value for gender	12-13 years (2,877; 60.05%)	14-15 years (1,914; 39.95%)	p value for age
Mental health								
Self-esteem (measured by RSES) n (%)	Low self-esteem	1,921 (40.10)	984 (39.85)	840 (39.75)	0.009 p for trend: 0.17	1,126 (39.14)	795 (41.54)	0.05 p for trend: 0.02
	Normal self-esteem	2,327 (48.57)	1,177 (47.67)	1,061 (50.21)		1,404 (48.80)	923 (48.22)	
	High self-esteem	459 (9.58)	269 (10.90)	175 (8.28)		297 (10.32)	162 (8.46)	
Social comparison scale (measured by SCR; score range = 11-110. Higher scores indicate more positively compare oneself with others while using social media) median (IQR)		57 (53-77)	59 (54-81)	56 (51-75)	0.00001	58 (54-80)	56 (51-75)	0.005
Mental wellbeing (measured by SWEMWBS) n (%)	Probable depression	937 (19.56)	421 (17.05)	453 (21.44)	< 0.0001 p for trend: <0.00001	521 (18.11)	416 (21.73)	< 0.0001 p for trend <0.00001
	Possible depression	517 (10.79)	237 (9.60)	253 (11.97)		305 (10.60)	212 (11.08)	
	Average mental wellbeing	1,702 (35.52)	870 (35.24)	777 (36.77)		1,016 (35.31)	686 (35.84)	
	High mental wellbeing	1,559 (32.54)	897 (36.33)	601 (28.44)		997 (34.65)	562 (29.36)	
Anxiety (measured by GAD7) n (%)	Minimal anxiety	1,979 (41.31)	1,111 (45.00)	782 (37.01)	<0.0001 p for trend <0.00001	1,254 (43.59)	725 (37.88)	<0.0001 p for trend <0.00001
	Mild anxiety	1,560 (32.56)	804 (32.56)	702 (33.22)		903 (31.39)	657 (34.33)	
	Moderate anxiety	724 (15.11)	336 (13.61)	348 (16.47)		415 (14.42)	309 (16.14)	
	Severe anxiety	444 (9.27)	171 (6.93)	247 (11.69)		267 (9.28)	177 (9.25)	
	No depressive symptoms	3,234 (67.50)	1,722 (69.74)	1,387 (65.64)	0.004	1,997 (69.41)	1,237(64.63)	<0.0001

Potential depressive symptoms (measured by KADS) n (%)	Possible depressive symptoms	1,482 (30.93)	711 (28.80)	691 (32.70)		834 (28.99)	648 (33.86)	
Sleep problems								
Sleep duration on weekdays (hours); mean (SD)		7.70 (1.04)	7.83 (1.08)	7.59 (0.96)	< 0.00001	7.82 (1.01)	7.53 (1.05)	< 0.00001
Sleep duration on weekends (hours); mean (SD)		9.64 (1.72)	9.65 (1.76)	9.62 (1.66)	0.62	9.67 (1.70)	9.58 (1.75)	0.09
Average sleep duration across the whole week (hours); mean (SD)		8.25 (0.96)	8.34 (0.99)	8.16 (0.91)	< 0.00001	8.34 (0.93)	8.10 (0.98)	< 0.00001
Sleep quality (measured by ASHS; score range =2-12; higher scores indicate higher quality of sleep) median (IQR)		9.67 (8, 10.83)	9.5 (8-11)	9.67 (8, 10.83)	0.95	9.67 (8- 11)	9.5 (7.83, 10.67)	0.004
Daytime sleepiness (measured by ASHS; score range = 1 to 6; lower scores indicate higher possibility of daytime sleepiness) median (IQR)		5.5 (4-6)	5 (4-6)	5.5 (4.5-6)	0.003	5.5 (4-6)	5 (4-6)	0.11
Time taken to fall asleep; n (%)	20 minutes or less	3,129 (65.31)	1,699 (68.81)	1,307 (61.86)	< 0.0001 p for trend: 0.002	1,860 (64.65)	1,269 (66.30)	0.70 p for trend: 0.20
	40 minutes or less	1,043 (21.77)	477 (19.32)	528 (24.99)		635 (22.07)	408 (21.32)	
	1 hour or less	262 (5.47)	115 (4.66)	132 (6.25)		164 (5.70)	98 (5.12)	
	More than 1 hour	309 (6.45)	155 (6.28)	124 (5.87)		191 (6.64)	118 (6.17)	
Times waking up per night; n (%)	0 time	2,814 (58.74)	1,526 (61.81)	1,172 (55.47)	< 0.0001 p for trend <0.00001	1,707 (59.33)	1,107 (57.84)	0.65 p for trend: 0.40
	1-2 times	1,589 (33.17)	762 (30.86)	761 (36.02)		955 (33.19)	634 (33.12)	
	>= 3 times	307 (6.41)	762 (5.55)	147 (6.96)		178 (6.19)	129 (6.74)	

Physical activity								
Number of days physically active for 60 minutes or more; n (%)	0-3 days	3,445 (71.91)	1,644 (66.59)	1,645 (77.85)	< 0.0001 p for trend: <0.00001	2,057 (71.50)	1,388 (72.52)	0.55 p for trend: 0.63
	4-6 days	751 (15.68)	461 (18.67)	268 (12.68)		467 (16.23)	284 (14.84)	
	7 days	553 (11.54)	347 (14.05)	177 (8.38)		330 (11.47)	223 (11.65)	
Weekly leisure time activity level (measured by Godin Leisure-Time Exercise questionnaire) n (%)	Sedentary	441 (9.20)	215 (8.71)	191 (9.04)	0.53 p for trend: 0.38	259 (9.00)	182 (9.51)	0.81 p for trend: 0.53
	Moderately active	558 (11.65)	270 (10.94)	251 (11.88)		334 (11.61)	224 (11.70)	
	Highly active	3,779 (78.88)	1,975 (79.99)	1,663 (78.70)		2,275 (79.08)	1,499 (78.32)	
WeChat Sports steps (average daily steps for one week); median (IQR)		4589 (1443-8500)	5000 (1502-9999)	4000 (1400-8000)	< 0.00001	5000 (1888-8658)	4000 (1041-8000)	0.55

Rosenberg Self-esteem Scale (RSES); Social Comparison Rating Scale (SCR); Short Warwick-Edinburgh Mental Wellbeing Scale (SWEMWBS); Generalized Anxiety Disorder 7 items (GAD-7); Kutcher Adolescent Depression Scale (KADS) ; Adolescent Sleep Hygiene Scale (ASHS)

3.2 Section B. Associations between screen time, mobile phone and social media use, and mental wellbeing, sleep and physical activity

3.2.1 Mental wellbeing

The association between screen time, mobile phone and social media use time, and mental wellbeing are reported in Table 4. Compared with adolescents who had no screen time, in both the unadjusted and adjusted models, those who had 0-1 hour of screen time had higher wellbeing (adjusted mean difference in score: 1.64; 95%CI: 0.91, 2.36) but there were no significant differences in wellbeing between the groups with more than one hour of daily screen time and those with no screen time. Adolescents reporting 1-2 hours, and over 2 hours daily mobile phone use had mean mental wellbeing scores that were 1.55 units lower (95%CI: -2.24, -0.86) and 1.61 units lower (95% CI: -2.59, -0.64) than adolescents reporting no daily mobile phone use, respectively. The adjusted association remained statistically significant only in adolescents reporting 1-2 hours of daily mobile phone use (adjusted mean difference: -1.09; 95%CI: -1.77, -0.40), and the mean difference in scores was smaller than in the unadjusted model. Regarding daily social media time and mental wellbeing, in the unadjusted model adolescents who used social media for 1-2 hours daily had a mean mental wellbeing score that was 0.87 units lower (95% CI: -1.55, -1.18) than adolescents who did not spend any time on social media. This association was not statistically significant after adjustment (Table 4). However, in the adjusted model, adolescents using social media for 0-1 hours daily had a mean mental wellbeing score that was 0.83 units higher (95% CI: 0.30, 1.36) than adolescents who did not spend any time on social media.

Regarding the frequency of social media checks and wellbeing, there was a trend towards lower mental wellbeing scores for those who check or post on social media almost daily, compared to very infrequent users, although most associations were not statistically significant. The pattern for frequency of social media checking in relation to mental wellbeing was more complicated. Mental wellbeing scores among those checking monthly or weekly were generally higher than those checking very infrequently, but these were not always statistically significant (see Table 7).

Table 4 Screen time, mobile phone and social media use and association with mental wellbeing

	Unadjusted model		Adjusted model*	
	Mean difference in SWEMWBS score (95% CI)	p value	Mean difference in SWEMWBS score (95% CI)	p value
Screen time				
0h	Ref		Ref	
0-1h	1.08 (0.35, 1.81)	p= 0.004	1.64 (0.91, 2.36)	p<0.0001
1-2h	-0.10 (-0.89, 0.70)	p= 0.81	0.56 (-0.23, 1.35)	p= 0.16
>2h	-0.43 (-1.32, 0.46)	p= 0.35	0.32 (-0.57, 1.21)	p= 0.48
Mobile phone time				
0h	Ref		Ref	
0-1h	0.16 (-0.37, 0.70)	p= 0.55	0.49 (-0.04, 1.02)	p= 0.07
1-2h	-1.55 (-2.24, -0.86)	p<0.0001	-1.09 (-1.77, -0.40)	p= 0.002
>2h	-1.61 (-2.59, -0.64)	p= 0.001	-0.84 (-1.82, 0.14)	p= 0.09
Social media time				
0h	Ref		Ref	
0-1h	0.49 (-0.04, 1.03)	p= 0.07	0.83 (0.30, 1.36)	p= 0.002
1-2h	-0.87 (-1.55, -1.18)	p= 0.01	-0.36 (-1.04, 0.32)	p= 0.30
>2h	-0.94 (-2.09, 0.22)	p= 0.11	-0.45 (-1.61, 0.70)	p= 0.44

*Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

3.2.2 Depressive symptoms

The association between screen time, electronic devices and social media use and depressive symptoms are reported in Table 5. In both the unadjusted and adjusted models, compared with adolescents who had no screen time, those reporting up to

one hour of screen time had lower odds of depressive symptoms (OR = 0.79; 95%CI: 0.63, 0.99), whilst those reporting higher screen time had higher odds of depressive symptoms (OR = 1.44; 95%CI: 1.11, 1.88 for >2 hours screen time).

Regarding average daily mobile phone use across the whole week, adolescents who reported over 1 hour of use, compared to non-users, had an increased odds of depressive symptoms in both the adjusted and unadjusted models. There was a dose-response relationship with the odds ratios for those using mobile phones for 1-2 hours and over 2 hours being 1.60 (95%CI: 1.31, 1.96) and 2.34 (95%CI: 1.77, 3.09) respectively in the adjusted models (Table 5).

In both the unadjusted and adjusted models, adolescents who used social media for 0-1 hours had lower odds of depressive symptoms (adjusted OR = 0.78; 95%CI: 0.67, 0.92) compared with those reporting no social media use. However, those reporting 1-2 hours or over 2 hours of social media use had higher odds of depressive symptoms (OR = 1.47; 95% CI: 1.21, 1.80 and OR = 2.21; 95%CI: 1.60, 3.06 respectively in the adjusted model) (Table 5). The association between the frequency of social media checking & posting and depressive symptoms had a consistent trend. Adolescents who checked social media weekly and almost every day had higher odds of depressive symptoms (OR = 1.21; 95%CI: 1.04, 1.41 and OR = 2.18; 95%CI: 1.78, 2.68 respectively in the adjusted model), compared with adolescents who checked social media very infrequently (see Table 7). Adolescents who posted on social media weekly and almost every day had higher odds of depressive symptoms (OR =1.50;

95%CI: 1.31, 1.72 and OR = 2.66; 95%CI: 1.96, 3.60, respectively), compared with adolescents who posted on social media very infrequently (see Table 7).

Table 5 Screen time, mobile phone and social media use and association with depressive symptoms

	Unadjusted model		Adjusted model*	
	Odds Ratio in Depressive symptoms (95% CI)	p value	Odds Ratio in Depressive symptoms (95% CI)	p value
Screen time				
0h	Ref		Ref	
0-1h	0.88 (0.71, 1.09)	p= 0.24	0.79 (0.63, 0.99)	p=0.04
1-2h	1.32 (1.04, 1.66)	p=0.02	1.17 (0.93, 1.49)	p= 0.19
>2h	1.64 (1.27, 2.11)	p<0.0001	1.44 (1.11, 1.88)	P=0.007
Mobile phone time				
0h	Ref		Ref	
0-1h	0.96 (0.82, 1.13)	p= 0.64	0.91 (0.78, 1.08)	p= 0.28
1-2h	1.72 (1.41, 2.10)	p<0.0001	1.60 (1.31, 1.96)	p<0.0001
>2h	2.64 (2.02, 3.46)	p<0.0001	2.34 (1.77, 3.09)	p<0.0001
Social media time				
0h	Ref		Ref	
0-1h	0.84 (0.72, 0.99)	p=0.04	0.78 (0.67, 0.92)	p=0.003
1-2h	1.62 (1.33, 1.97)	p<0.0001	1.47 (1.21, 1.80)	p<0.0001
>2h	2.28 (1.66, 3.13)	p<0.0001	2.21 (1.60, 3.06)	p<0.0001

*Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

3.2.3   Anxiety symptoms

The association between screen time, mobile and social media use time and anxiety symptoms are reported in Table 6. There was a consistent trend towards higher odds of anxiety with increasing screen, mobile phone, and social media use times in those using for 1-2 hours and >2 hours, compared to non-users, with almost all associations being statistically significant. In the adjusted models, the odds ratios for >2 hours of

use compared to non-users were 1.50 (95%CI: 1.13, 2.00) for screen time, 1.66 (95%CI: 1.24, 2.23) for mobile phone use and 2.38 (95%CI: 1.70, 3.34) for social media use. In the adjusted model, adolescents who checked social media almost every day had higher odds of anxiety symptoms, compared with adolescents who checked social media very infrequently (OR = 1.82; 95%CI: 1.46, 2.26). Regarding social media posting, in the adjusted model, adolescents who posted on social media weekly and almost every day had higher odds of anxiety symptoms compared to those posting very infrequently (OR = 1.39; 95%CI: 1.20, 1.60 and OR = 1.83; 95%CI: 1.34, 2.51, respectively) (see Table 7).

Table 6 Screen time, mobile phone and social media use and their association with anxiety symptoms

	Unadjusted model		Adjusted model*	
	Odds Ratio in Anxiety symptoms (95% CI)	p value	Odds Ratio in Anxiety symptoms (95% CI)	p value
Screen time				
0h	Ref		Ref	
0-1h	1.06 (0.84, 1.35)	p= 0.63	0.96 (0.75, 1.23)	p= 0.75
1-2h	1.39 (1.07, 1.79)	p= 0.01	1.26 (0.97, 1.63)	p= 0.09
>2h	1.69 (1.28, 2.23)	p<0.0001	1.50 (1.13, 2.00)	p=0.005
Mobile phone time				
0h	Ref		Ref	
0-1h	0.98 (0.83, 1.17)	p= 0.84	0.92 (0.77, 1.10)	p= 0.36
1-2h	1.55 (1.26, 1.92)	p<0.0001	1.47 (1.19, 1.82)	p<0.0001
>2h	1.89 (1.42, 2.51)	p<0.0001	1.66 (1.24, 2.23)	p=0.001
Social media time				
0h	Ref		Ref	
0-1h	0.93 (0.79, 1.11)	p= 0.43	0.87 (0.73, 1.03)	p= 0.11
1-2h	1.39 (1.13, 1.72)	p= 0.002	1.27 (1.03, 1.58)	p= 0.03
>2h	2.53 (1.83, 3.51)	p<0.0001	2.38 (1.70, 3.34)	p<0.0001

*Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

Table 7 Mental wellbeing, depressive symptoms and anxiety symptoms and their association with frequency of social media checking / posting

Frequency of social media checking and posting	Unadjusted		Adjusted*		Unadjusted		Adjusted*		Unadjusted		Adjusted*	
	Mean difference in SWEMWBS score (95% CI)	p value	Mean difference in SWEMWBS score (95% CI)	p value	Odds Ratio in Depressive symptoms (95% CI)	p value	Odds Ratio in Depressive symptoms (95% CI)	p value	Odds Ratio in Anxiety symptoms (95% CI)	p value	Odds Ratio in Anxiety symptoms (95% CI)	p value
Very infrequently (check)	Ref		Ref		Ref		Ref		Ref		Ref	
Monthly (check)	1.69 (-0.61, 3.99)	p= 0.15	2.01 (-0.25, 4.28)	p= 0.08	0.99 (0.49, 1.98)	p= 0.97	0.98 (0.49, 1.99)	p= 0.96	1.52 (0.77, 3.01)	p= 0.23	1.48 (0.74, 2.96)	p= 0.27
Weekly (check)	0.35 (-0.13, 0.84)	p= 0.15	0.56 (0.08, 1.04)	p=0.02	1.25 (1.08, 1.45)	p=0.002	1.21 (1.04, 1.41)	p=0.01	1.20 (1.02, 1.40)	p=0.03	1.16 (0.99, 1.37)	p= 0.06
Almost every day (check)	-0.76 (-1.46, -0.06)	p=0.03	-0.48 (-1.18, 0.22)	p= 0.18	2.23 (1.83, 2.72)	p<0.0001	2.18 (1.78, 2.68)	p<0.0001	1.83 (1.49, 2.26)	p<0.0001	1.82 (1.46, 2.26)	p<0.0001
Very infrequently (post)	Ref		Ref		Ref		Ref		Ref		Ref	
Monthly (post)	-1.77 (-3.55. 0.01)	p=0.051	-1.60 (-3.35, 0.15)	p= 0.07	1.27 (0.76, 2.11)	p= 0.37	1.25 (0.74, 2.09)	p= 0.40	1.33 (0.77, 2.29)	p= 0.31	1.25 (0.72, 2.17)	p= 0.43
Weekly (post)	-0.33 (-0.78, 0.12)	p= 0.15	-0.06 (-0.51, 0.39)	p= 0.79	1.56 (1.37, 1.78)	p<0.0001	1.50 (1.31, 1.72)	p<0.0001	1.49 (1.29, 1.71)	p<0.0001	1.39 (1.20, 1.60)	p<0.0001
Almost every day (post)	-1.63 (-2.70, -0.57)	p=0.003	-0.99 (-2.07, 0.08)	p= 0.07	2.93 (2.19, 3.93)	p<0.0001	2.66 (1.96, 3.60)	p<0.0001	2.03 (1.50, 2.76)	p<0.0001	1.83 (1.34, 2.51)	p<0.0001

*Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

3.2.4   Sleep duration

Associations between screen time, mobile phone and social media use time, and sleep duration are presented in Table 8. There was a linear relationship between longer average screen time use and lower sleep duration in both the adjusted and unadjusted models. Compared with those reporting no screen time, the mean difference in sleep duration was -0.15 hours (95%CI: -0.25, -0.05), -0.2 hours (95%CI: -0.31, -0.09), and -0.32 hours (95%CI: -0.44, -0.19) in adolescents reporting screen time of 0-1 hour, 1-2 hours, and over 2 hours respectively in the adjusted model. Adolescents reporting 1-2 hours and over 2 hours of daily mobile phone use had significantly lower sleep duration than adolescents reporting no use in both the adjusted and unadjusted models, with mean differences of -0.18 hours (95%CI: -0.27, -0.08) and -0.28 hours (95%CI: -0.41, -0.15) respectively in the adjusted model. Similarly, all levels of social media use were associated with lower sleep duration compared with no social media use. In the adjusted models, the mean differences for those reporting 0-1 hour, 1-2 hours and over 2 hours social media were -0.09 hours (95:CI: -0.17, -0.02), -0.14 hours (95%CI: -0.23, -0.05) and -0.31 hours (95%CI: -0.47, -0.16) respectively. Regarding the frequency of social media use patterns, adolescents who checked social media almost every day had a lower mean sleep duration by 0.14 hours (95% CI: -0.23, -0.04), compared with adolescents who checked social media very infrequently. Adolescents who posted on social media weekly and monthly had lower mean sleep duration than those posting very infrequently (-0.34 hours; 95%CI: -0.57, -0.11 and -0.11 hours; 95% CI: -0.16, -0.05, respectively) (see Table 11).

Table 8 Screen time, mobile phone time and social media time and the association with sleep duration

	Unadjusted model		Adjusted model*	
	Mean difference in sleep duration (hours) (95% CI)	p value	Mean difference in sleep duration (hours) (95% CI)	p value
Screen time				
0h	Ref		Ref	
0-1h	-0.13 (-0.23, -0.02)	p= 0.02	-0.15 (-0.25, -0.05)	p= 0.004
1-2h	-0.17 (-0.28, -0.06)	p= 0.003	-0.20 (-0.31, -0.09)	p<0.0001
>2h	-0.29 (-0.42, -0.17)	p<0.0001	-0.32 (-0.44, -0.19)	p<0.0001
Mobile phone time				
0h	Ref		Ref	
0-1h	-0.04 (-0.12, 0.03)	p= 0.23	-0.06 (-0.13, 0.02)	p= 0.13
1-2h	-0.15 (-0.24, -0.05)	p= 0.002	-0.18 (-0.27, -0.08)	p<0.0001
>2h	-0.26 (-0.39, -0.12)	p<0.0001	-0.28 (-0.41, -0.15)	p<0.0001
Social media time				
0h	Ref		Ref	
0-1h	-0.09 (-0.16, -0.02)	p= 0.02	-0.09 (-0.17, -0.02)	p= 0.01
1-2h	-0.12 (-0.22, -0.03)	p= 0.01	-0.14 (-0.23, -0.05)	p= 0.004
>2h	-0.34 (-0.50, -0.18)	p<0.0001	-0.31 (-0.47, -0.16)	p<0.0001

*Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

3.2.5 Sleep quality

Associations between screen, mobile phone and social media use time, and sleep quality are presented in Table 9. Consistent associations between average daily screen time, mobile phone and social media use and sleep quality scores were found in both the unadjusted and adjusted models, with a gradient according to the level of usage. Adolescents that reported over 1 hour of screen/mobile phone/social media time had significantly lower mean sleep quality scores, compared with adolescents reporting no screen/mobile phone/social media time. In the adjusted models, adolescents who reported screen time of 1-2 hours and over 2 hours had mean differences in sleep quality scores of -0.65 (95 %CI: -0.90, -0.41) and -1.17 (95%CI: -1.45, -0.90) units, compared with adolescents who had no screen time. Similarly,

adolescents who used mobile phones for 1-2 hours, and over 2 hours had mean differences in sleep quality scores of -0.71 (95%CI: -0.93, -0.50) and -1.41 (95%CI: -1.71, -1.10) units, compared with those reporting no mobile phone time (adjusted model). Adolescents who reported social media use of 1-2 hours and over 2 hours had mean differences in sleep quality scores of -0.78 (95%CI: -0.99, -0.57) and -1.53 (95%CI: -1.89, -1.17) units, compared with those reporting no social media use (adjusted model). Regarding pattern of social media use, adolescents with higher checking and posting frequencies had significantly lower sleep quality scores. Compared with adolescents who checked social media very infrequently, adolescents whose checked social media weekly and almost every day had mean differences in sleep quality scores of -0.49 (95%CI: -0.64, -0.35) and -1.49 (95%CI: -1.71, -1.28) units in the adjusted model. (see Table 11). Compared with adolescents who posted on social media very infrequently, adolescents who posted weekly and almost every day had mean differences in scores of -0.63 (95%CI: -0.77, -0.49) and -0.97 (95%CI: -1.30, -0.64) units in adjusted model (see Table 11).

Table 9 Screen time, mobile phone time and social media time and the association with sleep quality

	Unadjusted model		Adjusted model*	
	Mean difference in ASHS score (95% CI)	p value	Mean difference in ASHS score (95% CI)	p value
Screen time				
0h	Ref		Ref	
0-1h	-0.15 (-0.38,0.07)	p= 0.18	-0.16 (-0.39, 0.06)	p= 0.15
1-2h	-0.69 (-0.93, -0.44)	p < 0.0001	-0.65 (-0.90, -0.41)	p < 0.0001
>2h	-1.24 (-1.51, -0.96)	p < 0.0001	-1.17 (-1.45, -0.90)	p < 0.0001
Mobile phone time				
0h	Ref		Ref	
0-1h	-0.09 (-0.26, 0.07)	p= 0.26	-0.09 (-0.25, 0.08)	p= 0.29
1-2h	-0.77 (-0.98, -0.56)	p < 0.0001	-0.71 (-0.93, -0.50)	p < 0.0001
>2h	-1.53 (-1.83, -1.24)	p < 0.0001	-1.41 (-1.71, -1.10)	p < 0.0001
Social media time				
0h	Ref		Ref	
0-1h	-0.15 (-0.31, 0.02)	p= 0.08	-0.12 (-0.28, 0.05)	p= 0.17
1-2h	-0.87 (-1.08, -0.66)	p < 0.0001	-0.78 (-0.99, -0.57)	p < 0.0001
>2h	-1.58 (-1.93, -1.23)	p < 0.0001	-1.53 (-1.89, -1.17)	p < 0.0001

*Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

3.2.6 Daytime sleepiness

As shown in Table 10, increasing screen time, mobile phone and social media use time were associated with increased likelihood of daytime sleepiness. The association between screen time and daytime sleepiness was significant for all levels of screen time, with a gradient present. In the adjusted model, adolescents reporting over 2 hours of daily screen time were almost twice as likely to report daytime sleepiness (OR = 1.95, 95% CI: 1.52, 2.51), compared with those participants who reported no screen time. Again, a gradient was present in the association between daily mobile phone time and odds of daytime sleepiness, although there was no significant association between 0-1 hours mobile phone use and daytime sleepiness in the adjusted model. Adolescents reporting 2 hours of mobile phone use were twice as likely to report daytime sleepiness, compared with those reporting no phone use (OR

= 2.05; 95%CI: 1.55, 2.71, adjusted model). The association between social media usage time and daytime sleepiness showed a similar pattern to mobile phone use, with adolescents reporting over 2 hours of social media time having almost twice the likelihood of daytime sleepiness, compared with those reporting no social media use (OR = 1.97; 95%CI: 1.42, 2.73, adjusted model). Regarding the frequency of social media checking and posting and daytime sleepiness, adolescents checking and posting weekly and almost every day had a higher risk of daytime sleepiness (Table 11). Compared with adolescents who checked social media very infrequently, adolescents who checked social media almost every day were 2.21 (95%CI: 1.81, 2.69) times more likely to report daytime sleepiness. Compared to those posting very infrequently, adolescents posting almost every day were 2.52 (95%CI: 1.83, 3.46) times more likely to report daytime sleepiness (Table 11).

Table 10 Screen time, mobile phone time and social media time and their association with daytime sleepiness

	Unadjusted model		Adjusted model*	
	Odds Ratio in daytime sleepiness (low possibility of daytime sleepiness (score >=5.5) as a reference group) (95% CI)	p value	Odds Ratio in daytime sleepiness (low possibility of daytime sleepiness (score >=5.5) as a reference group) (95% CI)	p value
Screen time				
0h	Ref		Ref	
0-1h	1.24 (1.01, 1.51)	p= 0.036	1.23 (1.00, 1.51)	p= 0.047
1-2h	1.80 (1.45, 2.24)	p<0.0001	1.73 (1.38, 2.16)	p<0.0001
>2h	2.05 (1.60, 2.61)	p<0.0001	1.95 (1.52, 2.51)	p<0.0001
Mobile phone time				
0h	Ref		Ref	
0-1h	1.16 (1.00, 1.34)	p= 0.048	1.15 (0.99, 1.33)	p= 0.065
1-2h	1.80 (1.49, 2.17)	p <0.0001	1.69 (1.40, 2.05)	p <0.0001
>2h	2.25 (1.71, 2.95)	p<0.0001	2.05 (1.55, 2.71)	p <0.0001
Social media time				
0h	Ref		Ref	
0-1h	1.18 (1.02, 1.36)	p= 0.028	1.14 (0.99, 1.33)	p= 0.074
1-2h	1.89 (1.57, 2.28)	p <0.0001	1.76 (1.45, 2.13)	p <0.0001
>2h	2.02 (1.47, 2.77)	p <0.0001	1.97 (1.42, 2.73)	p <0.0001

*Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

Table 11 Sleep duration, sleep quality and daytime sleepiness and the association with frequency of social media checking / posting

Frequency of social media check and post	Unadjusted		Adjusted*		Unadjusted		Adjusted*		Unadjusted		Adjusted*	
	Mean difference in sleep duration (hours) (95% CI)	p value	Mean difference in sleep duration (hours) (95% CI)	p value	Mean difference in ASHS score (95% CI)	p value	Mean difference in ASHS score (95% CI)	p value	Odds Ratio in daytime sleepiness (score >=5.5 (low daytime sleepiness) as a reference group) (95% CI)	p value	Odds Ratio in daytime sleepiness (score >=5.5 (low daytime sleepiness) as a reference group) (95% CI)	p value
Very infrequently (check)	Ref		Ref		Ref		Ref		Ref		Ref	
Monthly (check)	-0.25 (-0.55, 0.06)	p= 0.11	-0.17 (-0.47, 0.13)	p= 0.26	-0.39 (-1.08, 0.30)	p= 0.26	-0.31 (-1.00, 0.37)	p= 0.37	0.97 (0.52, 1.81)	p= 0.92	0.94 (0.50, 1.76)	p= 0.84
Weekly (check)	-0.01 (-0.08, 0.05)	p= 0.68	-0.03 (-0.09, 0.03)	p= 0.37	-0.55 (-0.70, -0.40)	p < 0.0001	-0.49 (-0.64, -0.35)	p < 0.0001	1.41 (1.24, 1.61)	p < 0.0001	1.35 (1.18, 1.55)	p < 0.0001
Almost every day (check)	-0.13 (-0.23, -0.03)	p=0.009	-0.14 (-0.23, -0.04)	p=0.005	-1.57 (-1.79, -1.36)	p < 0.0001	-1.49 (-1.71, -1.28)	p < 0.0001	2.32 (1.91, 2.81)	p < 0.0001	2.21 (1.81, 2.69)	p < 0.0001
Very infrequently (post)	Ref		Ref		Ref		Ref		Ref		Ref	
Monthly (post)	-0.41 (-0.64, -0.18)	P=0.001	-0.34 (-0.57. -0.11)	p=0.003	-0.31 (-0.85, 0.23)	p= 0.26	-0.33 (-0.86, 0.21)	p= 0.23	1.02 (0.63, 1.65)	p= 0.92	1.07 (0.66, 1.73)	p= 0.79
Weekly (post)	-0.11 (-0.17, -0.05)	p<0.0001	-0.11 (-0.16, -0.05)	p=0.001	-0.66 (-0.80, -0.53)	p < 0.0001	-0.63 (-0.77, -0.49)	p < 0.0001	1.43 (1.26, 1.61)	p < 0.0001	1.43 (1.27, 1.62)	p < 0.0001
Almost every day (post)	0.001 (-0.16, 0.16)	p= 0.99	-0.02 (-0.18, 0.14)	p= 0.81	-1.10 (-1.43, -0.78)	p < 0.0001	-0.97 (-1.30, -0.64)	p < 0.0001	2.58 (1.90, 3.49)	p < 0.0001	2.52 (1.83, 3.46)	p < 0.0001

*Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

3.2.7 Numbers of days adolescents are physically active for at least 60 minutes

Associations between screen time, mobile phone and social media use time, and numbers of days of being physically active for at least 60 minutes are presented in Table 12. In both the unadjusted and adjusted models, there was a consistent significant association between screen time and the number of days being physically active for at least 60 minutes, with higher screen time associated with fewer number of days per week with at least 60 minutes of physical activity. In the adjusted model, the incidence rate ratios (IRR) for number of days per week with at least 60 minutes of physical activity for adolescents with 0-1 hours, 1-2 hours, and over 2 hours of screen time were 0.84 (95%CI: 0.80, 0.89), 0.82 (95%CI: 0.77, 0.87) and 0.75 (95%CI: 0.70, 0.81) respectively, compared with those reporting no screen time. Similar associations were found for the models exploring mobile phone and social media time, and number of days of being physically active for at least 60 minutes. For the social media models, compared with those reporting no social media use, the IRRs were 0.89 (95%CI: 0.85, 0.93), 0.88 (95%CI: 0.83, 0.93), and 0.82 (95%CI: 0.74, 0.91) for adolescents reporting daily social media time of 0-1, 1-2 and over 2 hours, respectively. Although there were some significant associations in the models exploring the association between frequency of social media checking and posting, and number of days with at least 60 minutes of physical activity, there were no clear trends in this area of focus (see Table 14).

Table 12 Screen time, mobile phone time and social media time and the association with number of days being physically active for at least 60 minutes

	Unadjusted model		Adjusted model*	
	Incidence Rate Ratio (IRR) in Number of days physically active for at least 60 minutes (95% CI)	p value	Incidence Rate Ratio (IRR) in Number of days physically active for at least 60 minutes (95% CI)	p value
Screen time				
0h	Ref		Ref	
0-1h	0.81 (0.77, 0.86)	p<0.0001	0.84 (0.80, 0.89)	p<0.0001
1-2h	0.81 (0.76, 0.86)	p<0.0001	0.82 (0.77, 0.87)	p<0.0001
>2h	0.75 (0.69, 0.80)	p<0.0001	0.75 (0.70, 0.81)	p<0.0001
Mobile phone time				
0h	Ref		Ref	
0-1h	0.86 (0.82, 0.89)	p<0.0001	0.89 (0.85, 0.93)	p<0.0001
1-2h	0.85 (0.80, 0.90)	p<0.0001	0.86 (0.81, 0.91)	p<0.0001
>2h	0.87 (0.81, 0.95)	p= 0.001	0.85 (0.79, 0.93)	p<0.0001
Social media time				
0h	Ref		Ref	
0-1h	0.86 (0.83, 0.90)	p<0.0001	0.89 (0.85, 0.93)	p<0.0001
1-2h	0.87 (0.83, 0.92)	p<0.0001	0.88 (0.83, 0.93)	p<0.0001
>2h	0.85 (0.77, 0.93)	p= 0.001	0.82 (0.74, 0.91)	p<0.0001

*Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

3.2.8   Weekly leisure time activity

As shown in Table 13, the associations between weekly leisure time activity, with screen time, mobile phone use, and social media time were in a different direction to the associations with number of days being physically active. Adolescents who reported 0-1 hour and 1-2 hours use, had significantly higher odds of a high-intensity weekly leisure time activity score compared with those reporting no screen/mobile phone/social media time. Screen time and social media time for >2 hours was also associated with greater odds of higher intensity weekly leisure physical activity, but the magnitude of effect was lower and not statistically significant. The odds ratios were slightly attenuated in the adjusted models, but the patterns remained the same. For

social media time, the odds of reporting high-intensity weekly leisure time activity for adolescents reporting 0-1 or 1-2 hours, compared to reporting no social media time were 1.81 (95%CI: 1.52, 2.14) and 1.63 (95%CI: 1.30, 2.04), respectively (Table 13). Regarding patterns of social media use, adolescents checking and posting weekly were 1.53 times (95%CI: 1.30, 1.80), and 1.30 times (95%CI: 1.12, 1.52) as likely to report high-intensity weekly leisure time activity, compared with adolescents who very infrequently checked and posted on social media in the adjusted models (Table 14).

Table 13 Screen time, mobile phone and social media use and their association with weekly leisure time activity

	Unadjusted model		Adjusted model*	
	Odds ratio (OR) in Weekly leisure time activity (low intensity as a reference) (95% CI)	p value	Odds ratio (OR) in Weekly leisure time activity (low intensity as a reference) (95% CI)	p value
Screen time				
0h	Ref		Ref	
0-1h	1.73 (1.39, 2.15)	p<0.0001	1.66 (1.33, 2.09)	p<0.0001
1-2h	1.66 (1.30, 2.12)	p<0.0001	1.67 (1.30, 2.15)	p<0.0001
>2h	1.34 (1.02, 1.76)	p= 0.033	1.31 (0.99, 1.73)	p= 0.06
Mobile phone time				
0h	Ref		Ref	
0-1h	1.37 (1.16, 1.63)	p<0.0001	1.34 (1.13, 1.60)	p=0.001
1-2h	1.26 (1.01, 1.57)	p=0.045	1.28 (1.02, 1.61)	p=0.037
>2h	0.94 (0.70, 1.27)	p= 0.69	0.94 (0.69, 1.29)	p= 0.72
Social media time				
0h	Ref		Ref	
0-1h	1.80 (1.52, 2.12)	p<0.0001	1.81 (1.52, 2.14)	p<0.0001
1-2h	1.58 (1.27, 1.96)	p<0.0001	1.63 (1.30, 2.04)	p<0.0001
>2h	1.37 (0.95, 1.97)	p= 0.09	1.32 (0.91, 1.92)	p= 0.15

*Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

Table 14 Number of days physically active for at least 60 minutes and weekly leisure time activity and their association with frequency of social media checking / posting

Frequency of social media check and post	Unadjusted		Adjusted		Unadjusted		Adjusted	
	Incidence Rate Ratio (IRR) in Number of days physically active for at least 60 minutes (95% CI)	p value	Incidence Rate Ratio (IRR) in Number of days physically active for at least 60 minutes (95% CI)	p value	Odds ratio (OR) in Weekly leisure time activity (low intensity as a reference) (95% CI)	p value	Odds ratio (OR) in Weekly leisure time activity (low intensity as a reference) (95% CI)	p value
Very infrequently (check)	Ref		Ref		Ref		Ref	
Monthly (check)	1.13 (0.94, 1.34)	p= 0.18	1.12 (0.94, 1.34)	p= 0.19	1.66 (0.73, 3.76)	p= 0.23	1.71 (0.75, 3.91)	p= 0.20
Weekly (check)	0.99 (0.96, 1.03)	p= 0.77	1.00 (0.96, 1.04)	p= 0.94	1.53 (1.31, 1.79)	p<0.0001	1.53 (1.30, 1.80)	p<0.0001
Almost every day (check)	0.94 (0.89 1.00)	p=0.049	0.93 (0.88, 0.99)	p=0.019	0.96 (0.77, 1.19)	p= 0.68	1.01 (0.80, 1.26)	p= 0.96
Very infrequently (post)	Ref		Ref		Ref		Ref	
Monthly (post)	0.83 (0.71, 0.98)	p= 0.023	0.85 (0.73, 1.00)	p=0.051	0.91 (0.53, 1.60)	p= 0.76	0.95 (0.55, 1.67)	p= 0.87
Weekly (post)	0.95 (0.91, 0.98)	p= 0.005	0.97 (0.94, 1.01)	p= 0.13	1.29 (1.11, 1.49)	p=0.001	1.30 (1.12, 1.52)	p= 0.001
Almost every day (post)	1.06 (0.98, 1.15)	p= 0.17	1.05 (0.96, 1.15)	p= 0.27	0.68 (0.49, 0.92)	p= 0.014	0.78 (0.56, 1.08)	p= 0.13

*Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

3.2.9 Variation in associations between social media use time physical activity among boys and girls, and adolescents of different ages (interaction analysis)

Interaction terms between gender and social media usage time & age and social media usage time were introduced as additional covariates into the models examining the association with physical activity. The coefficients for the interaction terms in the models are presented in Appendix 3. In the model with the outcome of the number of days being physically active for 60+ minutes, the interaction terms for gender and social media and age and social media were mostly statistically significant (see Appendix 3). Similarly, in the model with the outcome of the weekly leisure time activity, the interaction terms for gender and social media usage time and age and social media usage time were also mostly statistically significant (Appendix 3). Therefore, I explored subgroup differences further by replicating the models for boys and girls, and younger and older groups separately. These models are presented in Tables 15 -18.

Table 15 Adjusted association between number of days physically active for 60+ minutes and social media usage time by gender groups (Boys and girls)

Social media usage time	Boys' physical activity time (IRR) 95%CI	p-value	Girls' physical activity time (IRR) 95%CI	p-value
0h	Reference	-	Reference -	-
0-1 h	0.93 (0.88, 0.99)	0.02	0.82 (0.76, 0.88)	<0.0001
1-2 h	0.89 (0.82, 0.96)	0.001	0.84 (0.76, 0.92)	<0.0001
> 2 h	0.93 (0.82, 1.06)	0.31	0.71 (0.60, 0.83)	<0.0001

Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

For both boys and girls, daily social media usage time, compared with no use, was associated with fewer number of days that participants were physically active for 60+ minutes. However, in girls the magnitude of difference was greater, there was a linear relationship between increasing social media usage time and fewer physically active days and the associations were statistically significant. For boys, the association was not statistically significant for the >2 hours usage group (Table 15).

Table 16 Adjusted association between number of days physically active for 60+ minutes and social media usage time by age groups (Aged 12-13 group and aged 14-15 group)

Social media usage time	Aged 12-13 group' physical activity time (IRR) 95%CI	p-value	Aged 14-15 group' physical activity time (IRR) 95%CI	p-value
0h	Reference	-	Reference	-
0-1 h	0.86 (0.82-0.91)	< 0.0001	0.96 (0.89-1.03)	0.24
1-2 h	0.85 (0.79-0.91)	< 0.0001	0.95 (0.87-1.04)	0.30
> 2 h	0.76 (0.67, 0.88)	< 0.0001	0.92 (0.79, 1.06)	0.25

Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

For adolescents aged 12-13 years, daily social media usage time was associated with fewer days being physically active for 60+ minutes, compared with no social media use. This association showed a decreasing trend, with more time on social media being associated with fewer days being physically active for 60+ minutes. Social media use over 2 hours, was associated with 24% fewer physically active days (IRR: 0.76; 95%CI: 0.67, 0.88) compared with no social media use. For adolescents aged 14-15, there was no significant association between time spent on social media and the number of days physically active for 60+ minutes, though a non-significant trend of a negative

association between time spent on social media and number of days physically active for 60+ minutes was present (Table 16).

Table 17 Adjusted association between weekly leisure time activity and social media usage time by gender (Boys and girls)

Social media usage time	Boys' weekly leisure time activity (OR) 95%CI	p-value	Girls' weekly leisure time activity (OR) 95%CI	p-value
0h	Reference	-	Reference	-
0-1 h	1.93 (1.52, 2.45)	<0.0001	1.50 (1.15, 1.95)	0.003
1-2 h	1.29 (0.96, 1.73)	0.09	2.06 (1.43, 2.96)	<0.0001
> 2 h	2.13 (1.14, 3.97)	0.02	0.92 (0.54, 1.56)	0.75

Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

For both boys and girls, up to one hour spent on social media per day was associated with a significantly higher intensity of weekly leisure time activity, compared with no social media use. In the 1-2 hours usage range, only girls showed a significantly higher intensity of weekly leisure time activity (OR: 2.06; 95%CI: 1.43, 2.96), compared with girls with no social media time. However, for >2 hours of social media usage time, there was a difference seen between boys and girls. Boys who reported using social media for over 2 hours per day had 2.13 times greater weekly leisure time activity than boys reporting no social

media use (OR = 2.13; 95% CI 1.14, 3.97). For girls, there was no statistically significant difference in weekly leisure time activity, compared with girls reporting no social media use (OR = 0.92, 95% CI 0.54 1.56) (Table 17).

Table 18 Adjusted association between weekly leisure time activity and social media usage time in age groups (Aged 12-13 group and aged 14-15 group)

Social media usage time	Aged 12-13 group' weekly leisure time activity (OR) 95%CI	p-value	Aged 14-15 group' weekly leisure time activity (OR) 95%CI	p-value
0h	Reference	-	Reference	-
0-1 h	1.73 (1.39, 2.15)	< 0.0001	1.92 (1.46, 2.54)	< 0.0001
1-2 h	1.44 (1.08, 1.93)	0.01	1.88 (1.33, 2.66)	< 0.0001
> 2 h	1.31 (0.78, 2.19)	0.3	1.37 (0.79, 2.40)	0.27

Adjusted for age, gender, and parents' education level, different schools, and boarding & non-boarding schools

For both younger and older adolescent groups, daily social media usage time for up to two hours was associated with significantly higher intensity of weekly leisure time activity, compared with no social media use. However, there was a difference in the magnitude of the association, which was larger in the older adolescent group. Compared with non-social media users, adolescents aged 14-15 years with 0-1 and 1-2 hours use were 1.92 times (95%CI: 1.46, 2.54)

and 1.88 times (95%CI: 1.33, 2.66) more likely to have a higher intensity of weekly leisure time activity respectively. Compared with non-social media users, adolescents 12-13 aged years were 1.73 times (95%CI: 1.39, 2.15) and 1.44 times (95%CI: 1.08, 1.93) more likely to have a higher intensity of weekly leisure time activity (Table 18).

3.3 Sections C. Mediation analysis in the association between social media use time and physical activity time

3.3.1 Exploration of factors mediating the relationship between social media usage time and physical activity

The findings from this study so far have identified associations between the time adolescents spend on social media and health-related problems (mental health, sleep, and physical activity), where more time spent on social media has been associated with worse health-related problems, including depressive and anxiety symptoms, worsened sleep duration, quality and daytime sleepiness and reduced physical activity levels. This part of the thesis explores in more depth the relationship between social media use and physical activity,

namely exploring the factors that mediate relationships between time spent on social media and physical activity levels.

Previous studies have tended to focus mediation analysis on relationships between mental health and social media use, there is little mediation analysis exploring social media use and physical activity (Chapter 1). Despite this, previous literature has reported that in adolescents, greater amounts of time spent on social media is associated with less time spent engaged with physical activity (Shimoga et al., 2019). Equally, adolescents who spend less time on social media tend to be more physically active (Parker et al., 2021; Sampasa-Kanyinga and Chaput, 2016). According to some qualitative studies, social media plays a positive and supportive role in promoting physical activity, such as through peer encouragement and the dissemination of and engagement with content related to sport (Domin et al., 2022; Van Kessel et al., 2016b). Given the limited research focus on social media and physical activity, this chapter focuses on the mediators between social media usage time and physical activity time (defined in this study as the number of days per week being active for 60+ minutes), using GSEM.

3.3.1.1   Development of a predictive mediation model

Two key factors shaped the development of the model. Firstly, current mediation models for adolescents that focus on the association between social media use and mental health, suggest that sleep and physical activity are important mediating variables (Kelly et al., 2018; Raudsepp, 2019; Rutter et al., 2021). At the same time, some studies have also explored the presence of mental health (self-esteem, anxiety, depression) as the mediator in the association between social media use and sleep (Woods and Scott, 2016). However, there is a gap in the exploration of mediating variables between social media use and physical activity.

The second factor was the available evidence on the association between social media use and mental health and sleep, which is described in Chapter 3. Here I found that in the case of mental health (represented by depression), sleep problems (represented by sleep duration) and social comparisons there was evidence that these variables were correlated with physical activity. In a randomised controlled trial (RCT) of 790 university students Zhang et al. (2016a), social comparison on social media was shown to be an important factor in promoting physical activity. Fonseca et al. (2021), in a systematic review that included six articles from 11 different countries and a total of 5797 adolescent participants aged 6-19 years, showed that longer sleep duration and better sleep quality were associated with higher levels of physical fitness. A

systematic review by Wang et al. (2022), which included RCTs of retrieval exercise interventions for depression or depressive symptoms in adolescents (involving 15 articles containing 1331 adolescents), showed a positive effect of physical activity on improvement of depressive symptoms. In this review it was highlighted that moderate intensity physical activity was preferable for adolescents with depression and depressive symptoms.

Referring to previous literature, I developed a predictive mediation model. That is, to explore whether depression, sleep duration and social comparison are factors that mediate the effects of time spent using social media on time spent in physical activity. To better fit the model, additional literature relating to the mediation factors were considered. There is evidence suggesting a possible association between social comparison and depression in adolescents (De Vries et al., 2018; Keles et al., 2020). Sleep disturbance is recognised to be associated with depression in adolescents (Lovato and Gradisar, 2014), and shorter sleep duration has been associated with depressive symptoms (Foley and Weinraub, 2017; Zhang et al., 2017). Therefore, the potential correlation between these mediators was included in the model design.

The first step was to develop a potentially good-fitting model for adolescents based on the literature and my research. I generated three hypotheses to

develop the model. Longer time spent using social media is associated with higher depressive symptoms, more negative social comparison, and shorter sleep duration (hypothesis 1). Higher depressive symptoms, more negative social comparison, and less sleep duration is associated with lower physical activity time (hypothesis 2). Higher time spent using social media will be directly and indirectly associated with lower physical activity levels, through higher depressive symptoms, more negative social comparison, and less sleep duration (proposed mediators; hypothesis 3). The proposed model is shown in figure 9.

Figure 9 Proposed model of the associations between social media usage time, depressive symptoms, sleep duration, social comparison, and physical activity time (number of days being physically active for at least 60 minutes)
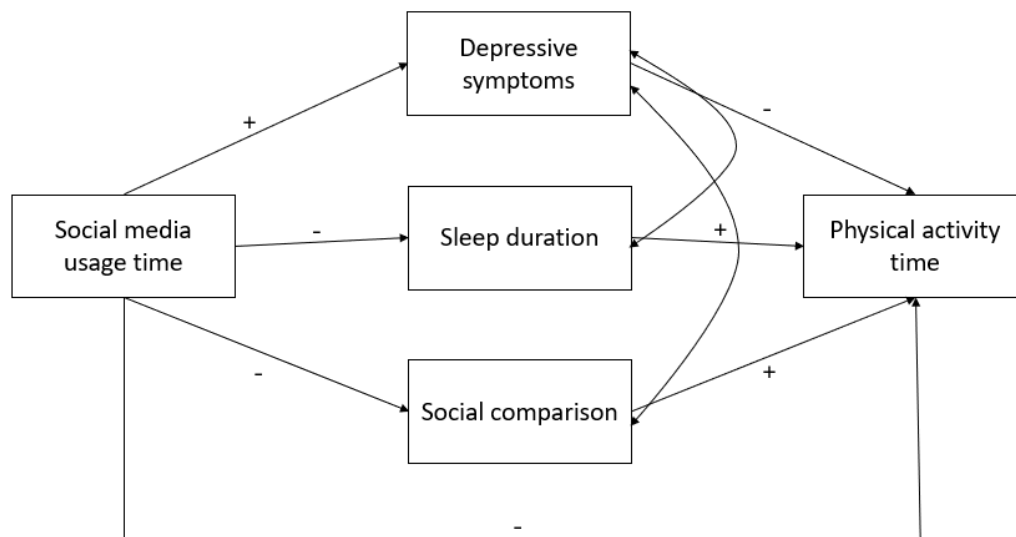
Note: + = positive association, - = negative association

The proposed model was examined using Generalized Structural Equation Modelling (GSEM) in STATA16. As some data included in the model were categorical (social media usage time, depressive symptoms) and accountable (physical activity time) or not normally distributed (social comparison), A Maximum Likelihood Robust (MLR) estimator with robust standard errors was used for analyses (Yuan and Bentler, 2000). Due to the use of GSEM, it was not possible to use Global fit indices to determine the goodness-of-fit of the model. The nlcom (non-linear combination of parameters) command was used to estimate the direct effect, indirect effect and total effect in this mediation model.

3.3.1.2   Results of mediation analysis

Figure 10 Structural equation model assessing the mechanisms of social media usage time on physical activity time (number of days being physically active for at least 60 minutes)
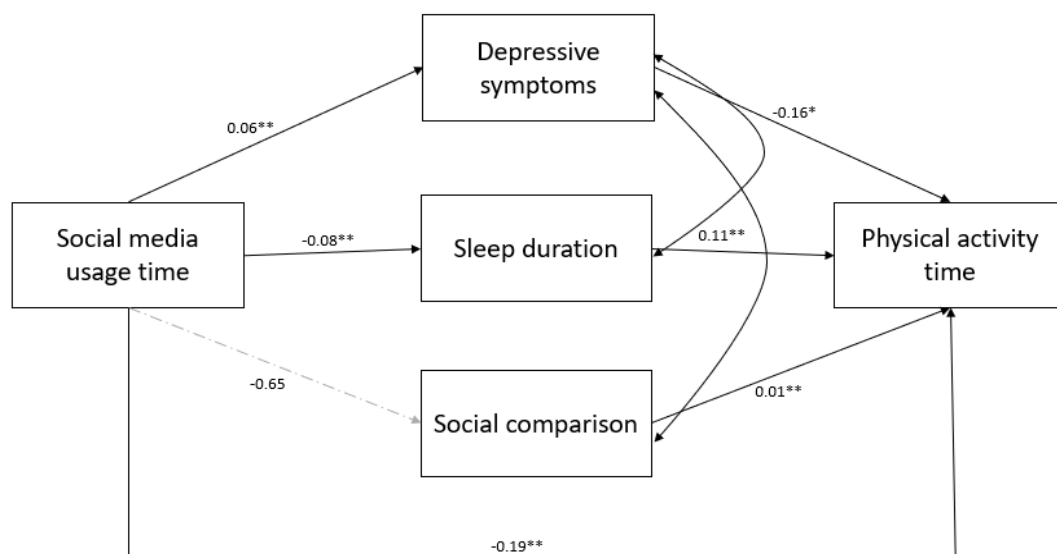
Note: Dashed lines represent non-significant paths*p < 0.05, **p < 0.001

The detailed results in GSEM are shown in Figure 10. The majority of coefficients were significant and demonstrated the expected patterns of associations. An exception was the path of social media usage time, social comparison, and physical activity time. Social media usage time was negatively associated with social comparison on social media, although this was non-significant, but social comparison on social media was positively associated with physical activity time, namely positive comparison on social media was associated with a higher number of days of being physically active for at least 60 minutes. Therefore, no indirect negative association was observed between physical activity time and social media usage time, through social comparison on social media. Social media usage time was positively associated with the possibility of depressive symptoms and in connection with this, a higher likelihood of depressive symptoms was associated with lower physical activity time. There was a negative association between social media usage time and sleep duration and in relation to this, there was a positive association between physical activity time and sleep duration. Turning to the association between social media usage time and physical activity time, the association between them was negative.

Based on these results of the GSEM analysis, there were partial mediation effects of depressive symptoms and sleep duration in the association between

social media usage time and physical activity time. Although the association between physical activity time and social media usage time, through social comparison on social media was not statistically significant, the association between physical activity time and social comparison on social media was statistically significant. In this case, the more positive social comparison was associated with higher physical activity time.

Table 19 Significant associations between social media usage time to physical activity time (number of days being physically active for at least 60 minutes)

Indirect path			β (Coefficient)	95%CI	p-value
Social media usage time >	Depressive symptoms >	Physical activity time	-0.01*	-0.02, -0.001	0.030
Social media usage time >	Sleep duration >	Physical activity time	-0.009*	-0.02, -0.001	0.022
Social media usage time >	Social comparison >	Physical activity time	-0.008	-0.02, 0.01	0.234
Direct effect			**β (Coefficient)**	**95%CI**	**p-value**
Social media usage time >		Physical activity time	-0.19*	-0.28, -0.10	<0.0001
Total effect			**β (Coefficient)**	**95%CI**	**p-value**
Social media usage time >	Depressive symptoms > Sleep duration > Social comparison >	Physical activity time	-0.22*	-0.31, -0.12	<0.0001

Note: PA= physical activity; *means showing statistically significant

Table 19 shows a full list of indirect effects, direct effects and total effects in the associations between social media usage time, potential mediators and physical activity time. Findings indicated that the relationship between social

media usage time and physical activity time was mediated by: depressive symptoms and sleep duration. The total indirect effect mediated by depressive symptoms and sleep time were -0.01 and -0.009 respectively in the association between social media usage time and physical activity time. Although the coefficients are not large, the p values were significant, so the mediation effects were present. Considering the total effect was -0.22 (p< 0.0001), the mediation effect of depressive symptoms and sleep duration accounts for 8.79% of the total effect.

CHAPTER 4 DISCUSSION OF QUANTITATIVE STUDY

4.1 Discussion of the descriptive analysis

4.1.1 Screen time, electronic devices and social media

In this study, participants reported less screen and mobile phone time on weekdays, and more on weekends. Social media time showed the same trend. This is likely to be due to the schedule of school students; on school days they have to attend school and follow the school schedule, and on the weekends, they may have more time to themselves. Especially, as in this study, four of the participating schools were boarding schools. This pattern of higher weekend use is consistent with previous studies (Ofcom, 2018; Toh et al., 2019). However, compared with these other studies, overall participants reported shorter usage time of screens, electronic devices and social media in this study. Based on the 2019 Ofcom survey, children aged 12-15 years used social media (different apps e.g. YouTube) on average for 3.45 hours per day and had an average of 1.68 hours of screen time (TV and films) per day (Ofcom, 2019). According to a 2021 report by the US agency Common Sense Media (a not-for profit organisation providing media advice to families), US adolescents aged 13-18 years have an average of 8.39 hours of screen time and 1.27 hours on social media per day (Rideout et al., 2021). Compared with these studies, in

this study, only 12.69% and 3.94% of participants reported more than two hours of screen time and social media time per day.

In this study, the types of content most often accessed by adolescents were related to participants' daily activities; entertainment and/or interactions with friends and family. Similar findings were reported in an online survey of 1316 US adolescents aged 13 to 17 years; around 10% of adolescents reported that social media was important to them because it allowed them to be exposed to new ideas, engage with issues they felt were important and reach out to others with similar views (Anderson et al., 2022). Also, communicating with friends and maintaining friendships are important elements when adolescents use social media, especially in 12-17 years-olds – a finding reported in a 2023 Ofcom survey aimed to British children and adolescents (age 3-17 years) (Ofcom.UK, 2023).

In this study, the most commonly reported reasons for using social media were related to talking to and checking in with friends and family, and accessing information related to entertainment, followed by accessing health information. However, the most common reasons differed among gender and age groups. Early studies of adolescent social media use showed that sociality was the primary reason for social media use among adolescents. Other reasons behind

social media usage in these studies included maintaining friendships, social identity gratification, escapism, information sharing, time-wasting, social capital and feedback on appearance (Allen et al., 2014; Barker, 2012; Clarke, 2010; Espinoza and Juvonen, 2011; Rodgers et al., 2021). In terms of using social media to access health information, there is evidence to suggest that adolescents show interest in searching for and obtaining health-related information (Baptist et al., 2011; Hedge and Donald, 2011; Park and Calamaro, 2013). Regarding social media use for entertainment, a series of focus groups with American adolescents aged 13 to 17 years conducted by the Pew Research Center (Anderson et al., 2022) provided similar findings to my study. Adolescents expressed their interest in and approval of the entertainment function of social media. These findings in relation to reasons for using social media in this and other studies makes sense in terms of the adolescent period of the life course. Adolescence is a time of rapid mental and social development with increased peer influence, a greater desire to belong, and an exploration of self and identity (Erikson, 1968; Neinstein, 2008; Viner et al., 2015). The interactive nature of social media promotes social interaction and increases feedback from others and social media provides platforms and opportunities for adolescents to explore more, which is in line with the needs of young people. According to boyd (2007), adolescents like social networking sites because they help them to form a social identity, understand more knowledge and

culture, and learn to get along with others in public life. This is part of the process of young people transitioning to adult society (boyd, 2007).

4.1.1.1 Gender and age differences in screen time, and use of electronic devices and social media

In this study, girls reported more time spent using screens, electronic devices and social media, compared with boys, which is consistent with previous evidence. A large survey that included 221096 US and UK adolescents aged 13-18 years showed that adolescent girls spend more time on social media, smartphones and the internet, and boys generally spend more time playing games on electronic devices (Twenge and Martin, 2020). A 2012 report by the Pew Research Centre claimed that girls and older adolescents were the heaviest users of social media in the US; 48% of adolescent girls used social media such as Facebook and Twitter several times a day, while only 36% of adolescent boys did the same (Madden et al., 2013).

In relation to the different types of content accessed, in this study, girls were more likely to access entertainment information, information about themselves, and information related to friends, family, or pets, whereas boys were more likely to access news and health information. According to Ofcom's 2023 survey

of British children and adolescents, social media games are very attractive to boys, and there are many types involved, including games similar to sports events (e.g., NBA and World cup). Boys also preferred to browse streaming videos (e.g., Youtube and Twitch) (Ofcom.UK, 2023). Turning to girls, the Common Sense Media report of a survey aimed at 1300 adolescent girls (age 11-15 years) only, more than two out of three girls engaged every day in social media content relating to entertainment and having fun (Nesi et al., 2023). In this study, girls posted more information about themselves, their daily activities, entertainment and their family and friends, compared with boys. This is in keeping with findings from previous studies. According to a Pew Research Centre survey with 743 US adolescents age 13-17 years, girls were more likely than boys to say they post about their family, emotions, and feelings (Anderson and Jiang, 2018b). The 2023 Ofcom report shows that in the UK girls are more likely than boys to show what they share, comment or post on social media, and they are more likely than boys to send messages to their friends (Ofcom.UK, 2023).

In terms of differences across age groups, older adolescents (age 14-15 years) reported higher screen time and time using mobile phones compared to the younger age group (age 12-13 years) in this study. The same was true for social media usage time, with older adolescents spending more time using social

media per day than younger adolescents. This is similar to Rideout et al. (2021)'s report in which they stated that US children aged 8-12 years spend 5.33 hours per day using screens, compared with 8.39 hours in teens aged 13-18 years. The 2012 Pew Research Centre survey with 802 adolescents aged 12-18 years old reported 26% of younger adolescents between the ages of 12 and 13 years used social media multiple times per day, compared with 47% of adolescents aged 14-17 years (Madden et al., 2013).

4.1.2 The overview of mental wellbeing, sleep, and physical activity among adolescents

In this study around 30% of the participants reported low wellbeing, 25% of participants had anxiety symptoms, and around one third of participants had depressive symptoms. This is broadly similar to mental wellbeing and mental health symptoms reported in other studies with adolescents. According to the UK Children's Society's Good Childhood Report in 2021 which reported findings of a survey with over 2000 children and adolescent participants aged 10 to 17 years, 12% of survey respondents indicated that they had low levels of wellbeing (The Children's Society, 2021). According to the US Centres for Disease Control and Prevention (CDC)'s Youth Risk Behaviour Survey report in 2021, 29% of high school students (around aged 14-18 years) reported that they lost energy or had poor mental health in the past 30 days (CDC, 2021).

Furthermore, in a systematic review, which included 72 studies covering a total of 324,859 adolescents aged 10-19 years from Asia, Europe, Africa, North America, the Middle East, Oceania and South America, the prevalence of depressive symptoms among adolescents was found to have increased from 24% between 2001 and 2010 to 37% between 2011 and 2020 (Shorey et al., 2022). Regarding anxiety, a meta-analysis including 29 studies with 80,879 participants aged 4-17 years, covering East Asia, Europe, North America, Central and South America, and the Middle East, showed that 20.5% of child and adolescent participants had symptoms of anxiety (Racine et al., 2021).

Regarding sleep, adolescents in this study had less than 8 hours of sleep on weekdays and more than 9 hours on weekends. In a study by Gariepy et al. (2020), 165793 adolescent school-age children (mean age was 13.5 years) from 24 European and North American countries had an average sleep time of 7.47 to 9.07 hours on school days and 9.31 to 10.22 hours on non-school days and average sleep duration was lower than 8 hours in only 4 of the 24 countries. Therefore, compared with most European countries, Chinese adolescents in this study had lower sleep time on school days but on weekends, they were inclined to sleep longer, similar to the findings of the European study. In this study, Chinese adolescents had poor sleep quality, which was reflected in the median score of 9.67 (IQR: 8, 10.83; the score range was 2-12, higher scores

indicate higher quality of sleep). A cross-sectional study to assess sleep in 1717 adolescents aged 13 to 16 years in three European countries (Spain, Iceland, and Estonia) reported similar findings, namely 44% of boys and 53% of girls experienced poor sleep quality (Galan-Lopez et al., 2021; Amaral et al., 2016).

In relation to daytime sleepiness, previous evidence suggests that excessive daytime sleepiness is also a health concern in many countries and may affect up to 40% of children and adolescents (Chung and Cheung, 2008; Gibson et al., 2006; Millman et al., 2005). However, the median score for daytime sleepiness in this study was 5.5 (IQR: 4-6; the score range was 1-6; lower scores indicate a higher possibility of daytime sleepiness), which suggests that daytime sleepiness in these adolescents was not a serious concern.

In this study, only around 12% of adolescents reported doing the recommended physical activity by the Chinese government of at least 60 minutes every day (GOV.cn, 2007). This is similar to physical activity guidelines also recommended by World Health Organization (WHO), namely adolescents aged 5-17 years should do at least an average of 60 minutes per day of moderate-to-vigorous intensity across the week (WHO, 2022). The level of activity reported by participants in this study is low in comparison to a large international cross-sectional study including 520533 adolescents from 105 countries and

territories, which showed that 17.2% of adolescents engaged in daily physical activity (at least 60 min per day) each week based on self-report (Marques et al., 2020). Moreover, a WHO survey, which included a sample of 146 countries and territories comprising 1.6 million adolescents aged 11-17 years in 2016, showed that globally 81.0% of students aged 11-17 years are physically inactive (Guthold et al., 2020). On the other hand, 79% of adolescents were in the higher intensity in weekly leisure time activity category in my study. A longitudinal study used data from 1103 participants, age 13 to 40 years (1990 to 2017) from the Norwegian Longitudinal Health Behaviour Study, to explore their leisure-time vigorous physical activity (LVPA). Between the ages of 13 and 18 years, there is a high level of LVPA, while from the age of 18 years onwards, LVPA levels began to gradually decline; LVPA continued to decline from adolescence to early adulthood (Mathisen et al., 2023). This may indicate the potential for higher intensity of physical activity in adolescence.

4.1.2.1 Gender and age differences in mental wellbeing, sleep, and physical activity

In this study, girls experienced worse mental wellbeing and more depressive symptoms and anxiety symptoms compared with boys. Other studies of adolescents have also revealed gender differences in depressive symptoms,

for example, data from a longitudinal study of 1567 adolescents aged 10-15 years in the United States showed that girls had higher levels of symptoms of depression and anxiety than boys (McLaughlin and King, 2015). Furthermore, according to 2 meta-analyses on sex differences in depression with data from 1716195 and 1922064 people in more than 90 different countries, gender differences peaked during adolescence, with depression and depressive symptoms more common in girls than in boys (Salk et al., 2017). Another study with a sample of 1200 Iranian secondary school students showed that compared to boys, girls scored higher on anxiety symptons (Hosseini and Khazali, 2013).

There were differences in self-esteem across gender in this study, with girls less likely to report high self-esteem and higher levels of wellbeing than boys. Again this is consistent with previous evidence; a study conducted in 2018, including 566829 adolescents aged 15 years old from 73 countries, explored data on four mental health outcomes: psychological distress, life satisfaction, happiness and wellbeing (Campbell et al., 2021). These outcomes differed across gender groups, with boys and girls showing very different mental health profiles. Overall, girls had poorer mental health than boys, and this gap was most pronounced for psychological distress and life satisfaction (Campbell et al., 2021).

In this study the findings showed that girls slept less than boys, but boys had more daytime sleepiness than girls. This is in contrast to some evidence from previous studies, which has shown that girls are more likely to report daytime sleepiness during weekdays (Lee et al., 1999b). Moreover, girls have been reported to have longer sleep time overnight (Yunus et al., 2021). Other research indicates that girls may also experience more frequent sleep-related difficulties. A cohort study from 2011 to 2015 in Germany, containing a sample of 855 children aged 4-9 years and 1047 adolescents aged 10-17 years reported these differences (Lewien et al., 2021). Again, this contrasts with my study, which did not find differences in sleep quality scores between boys and girls.

There were obvious differences in physical activity among gender groups in this study, as boys reported more days per week of doing at least one hour of physical activity than girls. There is extensive evidence to suggest that physical activity levels differ in adults, namely women have lower physical activity levels compared with men (Guthold et al., 2018). Differences between female and male adolescents show the same trend as that seen in adults. Data from a cross-sectional survey, including 1.6 million students aged 11–17 years from 146 countries, showed the prevalence of insufficient physical activity in male

adolescents to be 77.6%, but this figure was 84.7% in female adolescents in 2016 (Guthold et al., 2020).

In terms of age differences, older adolescents experienced worse depressive symptoms and anxiety symptoms compared with younger age adolescents in this study. Higher self-esteem and higher wellbeing was present in the younger age group than the older age group in this study. Yoon et al. (2022)'s study highlighted that older adolescents show higher rates and more obvious signs of psychological distress. A meta-analysis conducted by Racine et al. (2021), showed that 25.2% child and 20.5% adolescent participants (age 4 to 18) had symptoms of depression and anxiety, and showed that these symptoms were higher with increasing age, with slopes of 0.26 and 0.27 respectively.

This study showed the older adolescents slept less than the younger adolescents. In line with this finding, sleep data from a two-phase (2013-2014 and 2017-2018) cross-sectional health behaviour survey of 165793 adolescent school-age children (mean age was 13.5 years) from 24 European and North American countries showed that older adolescents slept less and went to bed later on school days compared to younger adolescents (Gariepy et al., 2020). In this study, there were also significant differences in sleep quality by age group with younger adolescents having slightly higher sleep quality scores,

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which is supported by some evidence, but is not a consistent finding in all studies. A cross-sectional survey of 7534 Portuguese students aged 11-20 years reported that both insomnia and daytime sleepiness were more prevalent among older adolescents (Amaral et al., 2016). However, a cohort study conducted in Germany including 1047 adolescents' (age 10-17 years), showed that younger adolescents may have more difficulties at bedtime (Lewien et al., 2021).

Regarding physical activity, the older age group and younger age group did not have a difference in the number of days that they were physically active for at least 60 minutes or physical activity intensity in leisure time in this study. This differs from previous studies that have shown that younger adoelscents may be more physically active than older adolescents. For example, a large international cross-sectional study of 520533 adolescents across 105 countries reported that physical activity levels declined with age, namely adolescents aged 15-17 years had lower physical activity levels compared with adolescents aged 11-12 years (Marques et al., 2020). In this study, the age range studied was narrower (age 12-15 years), which may explain why differences in physical activity levels between age groups were not observed.

4.1.3   Strengths and limitations

Strengths of this study included a varied sample of schools, a large number of participants and a very high response rate. Another strength is the multi-dimensional measurement of social media use (rather than only focusing on time spent on social media. This provides fuller information about social media use in Chinese adolescents (e.g. reasons for social media use, access to different information on social media), which furthers our understanding of social media use in this population. Additionally, aseries of validated measures of mental well-being and mental health were used here to measure mental health among adolescents.

A main limitation was the format of the survey design; a self-report questionnaire was used to collect data on screen, devices and social media use, and even though the students were informed in advance that their information would not be shared with the school or teachers, some students may have under-reported the time spent on these activities.

Another limitation was the   non-random sampling of schools (due to the pandemic impact), which may have affected the representativeness of the sample, although a purposive sampling approach was employed to mitigate this.

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In respect to physical activity assessment, only two very short self-reported measures were used, which is a further limitation. This also applies to sleep data, which is self-reported and not objectively measured. However, I have assessed several aspects of sleep in addition to time.

In future research, if one wishes to measure screen, electronic device, and social media uasge time more objectively, use of an app tracker, such as screen time on iPhones and iPads should be considered, which can also record the time spent on each app separately (Hunt et al., 2018). Screen time that was recorded on mobile phones was also asked for in this study, as a form of validation of self-reported data. However, the actual operation of collecting this data in the future may be complex, especially as adolescents have more and more electronic devices and more overlapping screen time (e.g using their phones while watching TV).

4.1.4 Summary

The descriptive analysis presented provides an understanding of Chinese adolescent behaviours relating to screens, devices and social media, and their physical and mental health, relating to mental health, wellbeing, sleep and

physical activity. Furthermore, the analysis has explored differences in these domains by gender and age.

In reference to previous evidence, compared with developed districts and countries, the social media usage time of the adolescent population (Chinese adolescents) in this study was lower. There were high levels of poorer mental health in this study sample, especially regarding depressive symptoms, which were more prevalent compared with studies conducted in other countries. In relation to sleep problems, shorter sleep duration, and poor sleep quality were similar to other international studies. Physical activity levels were lower for Chinese adolescents compared to other international populations. Girls and older adolescents spent more time on social media, experienced worse mental health problems, shorter sleep duration, and had worse sleep quality. In addition, girls also did less physical activity compared with boys. This study has addressed the gaps in knowledge of social media use and health-related outcomes in Chinese adolescents.

4.2 Discussion of analysis of associations between screen time, mobile phone and social media use, and health-related outcomes

4.2.1 Association between screen time, mobile phone use, social media and mental health and wellbeing

In this study, adolescents who reported screen time of up to one hour had higher mental wellbeing than those reporting no screen time. This is consistent with evidence from the US annual surveys of 8th (age 13-14 years), 10th (age 15-16 years), and 12th (age 17-18 years) grade students, conducted between 1991 and 2016 (n = 1.1 million), which indicated that adolescents with little screen time were the happiest (Twenge et al., 2018b). For adolescents in the 8th and 10th grades (age 13-16 years), daily screen time of 0.5-2 hours, and for 12th graders (age 17-18 years), daily screen time of 1-3 hours were associated with the highest happiness levels (Twenge et al., 2018b). A limitation of the Twenge et al. (2018b) study was the lack of a validated measure of happiness, but the study was conducted with a large population, which is a strength.

I found that daily mobile phone usage time of over 1 hour was associated with lower mental wellbeing. Evidence from the (Przybylski and Weinstein, 2017b) study supports these findings. They conducted a cross-sectional study in the UK involving 120115 adolescents aged 15 years, and reported an association between mobile phone time and mental wellbeing, measured by The Warwick Edinburgh Mental Well-Being Scale. Their findings suggested that moderate use of smart phones may be beneficial. They reported that the turning point for the association between mobile phone use (access to social media use and online chatting) and mental wellbeing was 1 hour 57 minutes for smartphone use on weekdays and 4 hours 10 min on weekends, i.e. usage times above these thresholds were associated with lower mental wellbeing (Przybylski and Weinstein, 2017b).

In my study, low levels of social media usage time (up to one hour) was associated with a higher mental wellbeing, Again, this finding is broadly consistent with previous research evidence. A longitudinal study involving 221096 adolescents aged 15 in the UK and 8-12 graders in the US (age 13-18 years) showed that light users of digital media (around 1-2 hours) reported the highest levels of well-being, compared to most digital media use (mobile, internet, social media, computers, etc.) In other words, the greatest drop in wellbeing exists between moderate and heavy users of digital

technology (Twenge and Campbell, 2019). Overall, although there was no numerical agreement with other studies, previous research, together with my study illustrates that small and moderate amounts of screen time and social media usage time are associated with better mental wellbeing.

Regarding screen time and depressive symptoms, in this study, adolescents who reported less than 1 hour of daily screen time had a decreased risk of depressive symptoms, but adolescents who reported over 2 hours of daily screen time had an elevated risk of depressive symptoms. There are some studies that show this U-shape in the association between screen time and depressive symptoms. A meta-analysis of observational studies examining the association (including twelve cross-sectional studies and four longitudinal studies) between screen time and depression was conducted by Liu et al. (2016), and the findings indicated a U-shaped relationship between depression and screen-based use among children and adolescents (age 5-18 years). Compared to adolescents who had no screen time, participants who claimed screen time of less than 2 hours per day had a lower risk of depression, with the lowest risk occurring in the group of adolescents whose screen time was 1 hour per day; for adolescents with over 2 hours of screen time the risk of depressive symptoms was higher (Liu et al., 2016).

Extending to social media, time using social media and depressive symptoms also showed a U-shaped association in my study; adolescents who reported less than 1 hour of daily social media use had a decreased risk of depressive symptoms, but adolescents who reported over 1 hour of daily social media use had a higher risk of depressive symptoms, compared with adolescents who had no social media time. The association between social media usage time and depressive symptoms also was U-shaped in the Liu et al. (2016) meta-analysis, with adolescents who reported 0-1 hour social media time having a decreased risk of depressive symptoms, but adolescents who reported 1-2 hours and over 2 hours having an elevated risk of depressive symptoms compared with adolescents who reported no social media time. Moreover, several studies of adolescents have found a non-linear relationship between depression and time spent on electronic devices and social media, with adolescents who generally spend an average of one hour per day on electronic devices and social media having the lowest likelihood of depression (Twenge et al., 2018a). The associations between screen time, social media usage time, and depressive symptoms were both U-shaped, with over 2 hours being considered high-risk for adolescents, especially in terms of depressive symptoms. The association between mobile phone use was not U-shaped in my study, however, over 1 hour of use was associated with increased risk of depressive symptoms, with the risk increasing with higher time spent on mobile phones.

There are many reasons for the non-linear association between social media usage time, mental wellbeing and depressive symptoms. A secondary analysis of data from a longitudinal study of adolescents aged 13 to 16 years in England explored the association between frequency of social media use and mental health, and found that the association between social media use and girls' well-being scores was moderated by cyberbullying, sleep and physical activity, i.e. cyberbullying, sleep time and physical activity reduced well-being scores, although this finding was only significant among girls (Viner et al., 2019). Physical activity may also play a role in the U-shaped association between social media usage and depressive symptoms. A cross-sectional study of social media use and a range of mental health outcomes (e.g., depression, anxiety symptoms, loneliness) among 4592 US adolescents aged 12-17 years found that physical activity partially moderated the association between social media use and depression and anxiety (Rutter et al., 2021). Sleep may be another potential factor to impact the non-linear association between social media usage and depressive symptoms. Data from a cross-sectional study of 362 Swiss adolescents aged 12-17 showed that sleep disturbance partially mediated the relationship between electronic media use and depressive symptoms (Lemola et al., 2015). This is supported by the Li et al. (2017) study, in which 1,015 middle school students in grades 7, 8 and 9 (age 12-16 years) from China found that insomnia partially mediated depression.

In this study, both for screen time and mobile phone use, over one hour of daily use was positively associated with anxiety symptoms. Similar findings were reported from the 2014 Ontario Child Health Study (Kim et al., 2020). This was a cross-sectional study involving 2320 Canadian adolescents aged 12-17 years. The study found a positive association between screen time use (when it surpassed 4 hours) and emotional anxiety, but this was only found for passive screen time (activities like using electronic devices to receive information, such as watching TV, movies or videos), and not for active screen time (activities like using electronic devices to play games, chat, surf the web) (Kim et al., 2020). The association between social media usage time and anxiety symptoms showed a similar trend to that with screen time and mobile phone time in this study, namely more than one hour of daily social media time was associated with higher odds of anxiety symptoms. Other studies report similar findings. Sampasa-Kanyinga and Lewis (2015) found that among adolescents (mean age was 14.1 years), using social media for more than two hours a day was associated with psychological distress. Moreover, data from 10930 adolescents (mean age was 15.8 years) in six European countries showed a positive relationship between heavy social media use (over 2 hours per day) and depression and anxiety (Tsitsika et al., 2014). A study by Yan et al. (2017) with 2625 middle school students (age 13–18 years) in China showed that spending more time on social media was positively associated with anxiety.

More frequent social media checking and posting (weekly and more) was associated with a higher possibility of depressive symptoms, and anxiety symptoms in this study. A longitudinal study conducted by Winstone et al. (2022) had similar findings. The study explored self-harm, depression, anxiety and well-being among 2456 adolescents aged 13 from 19 schools in Southwest England (Winstone et al., 2022), suggesting that adolescents with high levels of online browsing, content sharing and frequent messaging are more likely to experience poor mental health outcomes (anxiety and depression), compared to other adolescents who may not be as active on social media.

4.2.2 Association between screen time, mobile phone use, social media and sleep

In this study, longer screen time, and time spent using mobile phone and social media were associated with shorter sleep duration, lower sleep quality, and higher daytime sleepiness. The associations with sleep quality and daytime sleepiness were only seen when screen time, mobile phone time and social media time was over 1 hour. Associations between screen time, mobile phone time, social media time, and sleep have been reported previously, and much evidence is consistent with these findings. Brautsch et al. (2022)'s systematic review showed that mobile phone, computer, internet and social media use was associated with shorter sleep duration and poorer sleep quality based on 8

longitudinal studies and 35 cross-sectional studies of young people aged 16-25 years. These studies were judged to be moderate to high quality. Most studies exploring the association between mobile phones and sleep problems have reported that increased mobile phone use is associated with increased sleep problems (insufficient sleep and daytime sleepiness), although these associations are sometimes of borderline significance (Gaina et al., 2005; Söderqvist et al., 2008; Yen et al., 2008). A systematic review, which included 49 quantitative studies, examined the associations between electronic devices (such as mobile phones, TV, computer, and tablet), screen time, and social media, and sleep among 0–15-year-olds (Lund et al., 2021). For 6–15 year olds, strong associations of electronic media use and social media use with delayed bedtime, poor sleep quality, problems falling asleep were found (Lund et al., 2021). In terms of the association between social media use and sleep problems in older adolescents, a cross-sectional study of 180 Indonesian adolescents aged 16-17 years showed that longer time spent on social media was associated with a higher possibility of insomnia. A cross-sectional study of 969 older adolescents at a mean age of 18.46 years in Singapore also reported that increased social media duration was associated with decreased sleep duration and increased daytime sleepiness (Nasirudeen et al., 2017).

In this study, there were differences in the associations between social media usage time and the different measures of sleep. Time spent on social media was negatively associated with sleep duration, compared with no social media use, and there was a linear relationship with higher time spent on social media associated with greater reductions in sleep duration. Whereas with sleep quality and daytime sleepiness, the negative associations only occurred at over 1 hour of daily social media use. The reason for the linear association seen with social media use and sleep duration may be related to the displacement of sleep, but the relationship of social media use with sleep quality and daytime sleepiness may be more complex.

Drawing on previous literature, sleep problems relating to social media can be summarised into three aspects:

1. Lacking sleep duration: time spent using social media may displace sleep directly or indirectly by displacing other daytime activities (Mahase, 2019; Scott et al., 2019) (such as homework, physical activity, etc.);

2. Delaying and disrupting sleep: due to online interactive activities before bedtime which may cause emotional and mental arousal (Munezawa et al., 2011), leading to sleep onset time being postponed (Cain and Gradisar, 2010; Levenson et al., 2017); and

3. Light or sound exposure causing sleep disruption: social media use may also have an impact on the quality of sleep via increased arousal, not

only simply through light or sound exposure (Chang et al., 2015; Cho et al., 2015).

The first point is a relatively straightforward explanation for the lack of sleep time brought about by social media, i.e., the deprivation of sleep by social media activity. The second and third points direct attention more to an underlying reason why sleep quality is affected by social media activity and explain why the relationship between sleep quality and social media is complex and multi-dimensional. Some clues also can be found in other studies. A two-wave longitudinal study of 2708 Dutch secondary school students (mean age was 13.86 years) examined the association between frequency of social media use and sleep duration and quality, and whether parental and restriction of social media contributed to adolescents' sleep. Parental restriction included preventing the use of social media by adolescents in the hour before bedtime and restrictions on adolescents bringing electronic devices into bedrooms at bedtime (van den Eijnden et al., 2021). The findings suggested that parental involvement may help to increase bedtime and improve sleep quality, but this was limited to less engaged social media users (van den Eijnden et al., 2021). For the adolescents who were highly engaged in social media (higher frequency of social media use and higher level of problematic social media use), parental rules were no longer associated with improved bedtime and sleep (van den Eijnden et al., 2021). This may indicate that the issue of sleep quality is more

complex than sleep duration, with more factors impacting sleep quality. Time restrictions on social media or electronic devices alone do not make a significant difference, especially for heavy use, but have a good effect on low level use, which may partly explain why only the medium to high level of users had lower sleep quality in this study.

In terms of the associations between frequency of social media posting and checking, and sleep problems, higher frequencies of both checking and posting on social media were associated with shorter sleep duration, lower sleep quality and higher possibility of daytime sleepiness. A series of previous cross-sectional studies have consistently shown that the frequency of social media use is associated with a range of sleep problems in adolescents, including shorter sleep duration (Arora et al., 2014; Reynolds et al., 2019) and poorer sleep quality (Akçay and Akçay, 2018; Woods and Scott, 2016).

4.2.3 Association between screen time, mobile phone use, social media and physical activity

In this study, screen time and mobile phone time were both negatively associated with the number of physically active days (>= 60 minutes physical activity) per week. This is consistent with previous studies. A large cross-sectional survey containing 24800 American high school students (age 14-18

years) showed that around one fifth of adolescents used screen-based devices for over 5 hours, and this level of screen device use was associated with inadequate physical activity (< 60 minutes of physical activity per day) (Kenney and Gortmaker, 2017). In addition, a survey of 436 adolescents aged around 18 years in the US and Thailand on smartphone use (Penglee et al., 2019) found that greater smartphone use per day was inversely associated with the number of days per week engaging in physical activity, although this was only observed among Thai students and not American students. The authors attributed this difference to the fact that American students generally participate in sufficient physical activity, whereas Thai students do not, possibly due to differences in socio-cultural and environmental factors between the US and Thailand, with the US taking a number of measures at the policy level to encourage physical activity. Overall, the results of my study were aligned to the results of Thailand adolescents. As both are Asian countries, they may have similar cultural backgrounds and attitudes related to physical activity.

In this study, time spent on social media was negatively associated with the number of days being physically active. There is little research evidence relating to the association between social media use and physical activity. A cross-sectional study was conducted in Canada by Sampasa-Kanyinga and Chaput (2016), who found that male adolescents (age 12-18 years) were more likely to

meet physical activity recommendations if they were infrequent social media users (less than 2 hours per day). For participants who spent more than 2 hours on social media daily, the authors suggested that their weekly leisure time was being replaced by more sedentary time, for instance social media time. Previous evidence has suggested that negative impacts of higher screen time and social media use seen in adolescents (e.g., on mental health and physical health) may be due to the possibility that screen time and social media use are substituting important other outdoor activities (e.g., physical activity) (Busch et al., 2014; Oswald et al., 2020; Twenge et al., 2019; Viner et al., 2019). This explanation may apply to the findings of this study, with more time spent on social media displacing physical activity time.

Of note in this study is the association between weekly leisure time activity and social media usage time, showing that less than 2 hours daily social media users reported more weekly recreational physical activity compared with those not using social media, while there was no significant difference in this activity between over 2 hours' users and non-users. Some evidence supports this finding. Shimoga et al. (2019) explored the relationship between social media use and physical activity by constructing generalised ordered logistic regression models. They asked the question: 'How often do you exercise vigorously?' and divided participants into three physical activity groups based

on their responses: never/seldom (low physical activity); sometimes (moderate physical activity); or every day (high physical activity). Shimoga et al. (2019) explored the relationship between physical activity and social media use across these three groups and reported that the relationship between social media use and physical activity depends on the usual level of physical activity. In students with low physical activity levels, there was a linear relationship with social media use, with more frequent social media use associated with lower physical activity. In students with high physical activity levels, the linear relationship was in the opposite direction with more frequent social media use associated with higher physical activity. In the students with moderate physical activity levels the relationship was not linear, with moderate social media use associated with higher physical activity. In summary of Shimoga et al. (2019)'s study, adolescents were physically active anyway, and social media use can reinforce this, but if they were physically inactive, social media use was likely to reinforce sedentary behaviour. For those who were moderately active, moderate social media users seemed to be associated with the highest physical activity. To some extent, Shimoga et al. (2019) study aligned with the findings of this study, where adolescents who moderately used social media tended to have higher intensity of leisure physical activity. Moderate use of social media may play a positive role in this association.

Further evidence on relationships between social media and physical activity, supports the findings of this study exemplifying positive relationships. A survey including 963 adolescents (mean age was 16.2 years) explored associations between social media use (e.g. streaming services for exercise subscriber fitness programs via apps etc.) and adherence to the physical activity guidelines (Parker et al., 2021). The study reported that adolescents who used social media to engage in physical activity had higher moderate- to vigorous-intensity physical activity and time spent doing muscle-strengthening exercises, compared to social media non-users. From another angle, reasonable social media use may provide a positive impact on physical activity. A systematic review of 18 articles (quantitative, qualitative and mixed methods) on adolescents aged over 13 years old showed that social media interventions can positively change physical activity based on the diverse uses social media offers such as gaming, image sharing and group chats, as these affordances of social media further encourage more engagement with physical activity (Goodyear et al., 2021b). In this study, moderate social media usage was associated with higher intensity of leisure physical activity, which may also lead to social media bringing out some benefits for physical activity.

4.2.4 Differences between boys and girls in the association of social media use with physical activity

There were differences across boys and girls in the association between social media usage time and numbers of days of being physically active for at least 60 minutes, with a stronger and more linear inverse association in girls. Although there is not much direct evidence to support differences in the association between social media usage time physical activity across gender groups, there is some. A longitudinal study conducted with 12866 adolescents in England aged 13-16 years, showed that in girls, frequent social media use appears to be detrimental to health, mediated by cyberbullying and/or insufficient sleep or exercise (Viner et al., 2019). An inverse correlation was reported between the frequency of social media use and frequency of physical activity among girls, however, the opposite was found in boys, with a positive correlation between frequency of social media use and physical activity (Viner et al., 2019). Further, more results suggested that social media use did not replace physical activity time in boys in the way that is does in girls (Viner et al., 2019). These findings are similar to the findings in this study, namely social media may lead to more negative impacts on physical activity in girls compared with boys.

There were differences in the association between social media usage time and weekly leisure time activity in boys and girls. For boys, using social media for over 2 hours was associated with a higher intensity of weekly leisure time activity. In terms of girls, less than 2 hours of social media use was associated with higher intensity of weekly leisure time activity. There was not much evidence in the literature on social media usage time and weekly leisure time activity intensity for boys and girls. Some reasons for this discrepancy may be seen from Mahon and Hevey (2021)'s qualitative study, which was a study aimed at exploring body image and social media use. This qualitative study in Ireland involving 29 adolescents aged 15-16 years (23 girls and 6 boys) showed that girls tended to respond more negatively to social media, which they perceived as having a negative impact on their body image, for instance dealing with less comfortable content (i.e., comparing their appearance with that of celebrities), but boys were inclined to actively seek out and select positive content that motivated them to exercise or helped their body image (Mahon and Hevey, 2021). In this context, boys and girls may differ in their motivation to engage in physical activity based on their responses to physical activity-related content on social media. However, the authors also suggest that the number of boys in this study was relatively small and that a larger sample size may be needed to support this (Mahon and Hevey, 2021). In summary, accessing physical activity content on social media may impact boys and girls differently,

girls may have a negative attitude towards it, in contrast, boys may hold a positive attitude, which may cause the difference.

4.2.5 Differences between younger and older adolescents in the association of social media use with physical activity

Daily social media use of up to two hours was associated with less days of being physically active for 60+ minutes for adolescents aged 12-13 years, but not for adolescents aged 14-15 years. For weekly leisure time activity, both younger and older adolescent groups showed a similar trend; daily social media for up to two hours was associated with higher intensity of weekly leisure time activity, compared with no social media use, though the 14-15 year-old group presented higher intensity. These findings suggests that older adolescents may have more self-control related to social media use, and for younger adolescents, they may be more easily distracted by social media reducing the time available to engage with physical activity. The potential logic may relate to older adolescents being more mature and higher frequency social media users (compared with younger adolescents) (Madden et al., 2013); they acquire and familiarise themselves with content on social media, learning to distinguish and utilise physical activity information and content to improve their weekly leisure time activity. However, there is little evidence that supports the associations

between physical activity time, leisure time activity and social media use in different age groups.

4.2.6 Strengths and Limitations

This study has contributed to the understanding of current Chinese adolescents' screen time, electronic devices use and social media use in relation to health outcomes (mental health, sleep and physical activity). It can add value to understanding what reasonable social media use may look like and inform how to engage and improve physical activity for Chinese adolescents further. Moreover, the results, which combine data from rural and urban 12-15-year-olds, provide a comprehensive picture of screen time, mobile phone and social media use, and various health-related outcomes among Chinese youth in this age group, especially given that social media has changed and developed and there is very little recent evidence, particularly in the younger adolescent age group. This study also explored the differences in the relationships between social media use and physical activity across age and gender subgroups by exploring interactions within the models. However, this study has some limitations that may affect the generalisability of the findings. Firstly, this study is cross-sectional and inevitably cannot provide evidence of causal relationships. Second, categories for social media usage time were used in the analysis as the previous literature suggests that there

were non-linear relationships between social media use and the health outcomes that were investigated (Przybylski and Weinstein, 2017b; Twenge and Campbell, 2019), but higher usage times above 2 hours were not differentiated in this study. In future studies, further impacts on screen, device, and social media usage time could be explored by expanding the categories of time beyond two hours. Furthermore, capturing more precise data on usage time may give more nuanced evidence and enable further exploration of the relationships between social media use and health outcomes (Twenge, 2019).

4.2.7 Summary

In this chapter I have presented a series of associations between screen time, mobile phone time, social media usage time, and health-related outcomes. Overall, over 2 hours per day on screen time, mobile phones, and social media was associated with a higher risk of anxiety and depressive symptoms, whereas social media usage time in 0-1 hour per day may be beneficial as it is associated with better mental welling and lower depressive symptoms. In relation to sleep, exposure to a longer time on digital screens and using social media was associated with shorter sleep duration, but a low amount of exposure (0-1 hour per day) may not be associated with worse sleep quality. Regarding physical activity, more time using social media was associated with fewer days being physically active for at least 60 minutes. However, with leisure

time activity, social media usage time of up to 2 hours per day was associated with higher intensity of weekly leisure activity, but this association was not present with higher levels of daily social media use (over 2 hours per day). A further finding relating to physical activity-related variables included a stronger inverse association between social media usage time and numbers of days of being physically active for at least 60 minutes in girls. In connection with this, a stronger positive association between social media usage time and weekly leisure time activity was seen in boys. In terms of different age groups, only the younger group of adolescents (age 12-13 years) showed a negative association between social media usage time and numbers of days were physically active for at least 60 minutes. Besides, both younger (age 12-13 years) and older (age 14-15 years) groups showed a positive association between social media use (up to 2 hours per day) and weekly leisure time activity.

4.3 Discussion of Analysis exploring factors mediating the relationship between social media use and physical activity

The mediation analysis explored whether depression, sleep duration, and social comparison are factors that mediate the effects of time spent on social media on time doing physical activity (numbers of days adolescents are

physically active for at least 60 minutes). Based on the GSEM results, partial mediation effects of depressive symptoms and sleep duration were presented in the association between social media usage and physical activity time. However, social comparison did not seem to be a significant mediating factor in the relationship between social media usage and physical activity time in the model.

4.3.1 Depressive symptoms as a mediator in the association between social media usage and physical activity time

In the mediation analysis, the path from social media usage time to depressive symptoms, and physical activity time, showed a negative association. In Chapter 4, section 4.2 the association between social media usage and physical activity time (negative association), and between social media usage time and depressive symptoms (U shaped association) has been discussed. Here, the point to be discussed is in reference to the association between depressive symptoms and physical activity time. Depression is associated with a spectrum of psychological, behavioural, and physical symptoms, including fatigue, lack of interest in activities, overwork, and reduced leisure time, all of which may negatively influence the ability to do physical activity (Cassano and Fava, 2002; Guze, 2006; Judd and Akiskal, 2000; Kendler and Gardner Jr,

1998). Yet, as this study was cross-sectional, it is hard to explore the causal relationship in the mediation path, and it is plausible that this direction also could be reversed. In turn, many studies have shown that physical activity has a positive impact on adolescent mental health (Axelsdottir et al., 2021; Graf et al., 2014; Rose and Soundy, 2020). A scoping review of 30 studies of youths with an average age of 12-25.9 years showed that different intensities of physical and exercise interventions and participation may lead to a reduction in depressive symptoms in young people (Pascoe et al., 2020). A study examining the relationship between physical activity and the risk of depression in 896 adolescents (age 10-19 years) using three waves of data from the 2020 Chinese Household Tracking Survey argued that adolescents who reported a lower frequency and shorter duration of physical activity had a significantly higher possibility of having depression, compared to those who were more physically active and for longer duration. Gu (2022) also emphasises that it is not only physical activity duration but also the fact that a wider range of physical activities (e.g., housework) can have a positive effect on mental health.

4.3.2 Sleep duration as a mediator in the association between social media usage and physical activity time

In the mediation analysis, the path from social media use to sleep duration, and physical activity time, showed a negative association. In Chapter 4 section 4.2, I discussed the association between social media use and physical activity (negative association), and between social media use and sleep duration (negative association). Here, the point to be discussed is in reference to the association between sleep duration and physical activity time. The association between sleep duration and physical activity time shown in this study's mediation model is well recognised (Garaulet et al., 2011; Jean-Louis et al., 2000; Kobel et al., 2019). For example, a systematic review of the relationship between sleep duration and cardiorespiratory fitness and muscle health, included 6 articles from 11 different countries and 5797 children and adolescents aged 6-19 years. The results showed that longer sleep duration and better sleep quality were associated with higher levels of physical activity (Fonseca et al., 2021), which is consistent with the association seen in my model. Furthermore, a study containing 5625 participants aged 14-18 years from the 2019 National Youth Risk Behaviour Survey dataset (YRBS) showed that adolescents who exercised for at least 60 minutes on five or more days per week were more likely to report sleeping eight or more hours on school days (Ganz et al., 2022). It is worth noting that the above studies are cross-sectional, which was the same as my study, so it was difficult to judge the direction of the associations. Dolezal et al. (2017)'s systematic review provided evidence about physical activity engagement promoting sleep duration. The systematic review

was conducted to summarise the effects of exercise interventions on sleep. The inclusion criteria for the study included an exercise intervention and sleep measures, with thirty-four studies in total comprising 506649 children, adolescents, adults, and older adults of all ages. With the exception of four studies that found no differences and one that reported a negative effect of exercise on sleep, the remaining findings supported that no matter what level and intensity of exercise is undertaken, it can improve the duration of sleep (Dolezal et al., 2017).

4.3.3   Strengths and Limitations

This mediation analysis explored the mediating factors between social media use and physical activity time that were presented in Chapter 3, section C. Depressive symptoms and sleep duration mediated the association between social media use and physical activity time. The majority of studies exploring mediating factors focus on factors mediating the relationship between social media use and mental health, therefore, this study therefore provides a new focus. On the other hand, the mediation analyses provided more comprehensive insights into how social media use is linked to more adolescents' health issues, especially in terms of physical activity. Yet a limitation of the cross-sectional study that was undertaken is that the causal relationship between independent variables and dependent variables cannot

be explored, and causal links also could plausibly be reversed. the use of GSEM for mediation analysis, global fit indices could not be used to assess the goodness-of-fit of the model. While there are methods such as using AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) that can be used to assess the global fit of GSEM models, they can only be used when comparing two models.

4.3.4   Summary

This chapter explored the potential role of depressive symptoms, sleep duration and social comparison as mediators of the relationship between social media usage time and physical activity time. After testing, depressive symptoms, and sleep duration may mediate the negative association between social media use and physical activity time, but social comparison did not mediate the association between social media use and physical activity time, in this model.

CHAPTER 5 QUALITATIVE STUDY

5.1 Aims and objectives of qualitative study

The participants of the qualitative study were chosen from the cross-sectional study. Two schools from the six schools that participated in the cross-sectional study (presented in Chapter 2) were included in the qualitative study.

The objectives of the qualitative study were to:

1. Explore why and how adolescents use social media

2. Explore the types of social media content that adolescents' access in relation to physical activity, and the reasons for their choices

3. Explore the influences of different social media content on adolescents' physical activity attitudes, knowledge and/or behaviours

4. Explore the risks and opportunities that adolescents report in relation to their uses of social media for their physical activity engagement.

Initially random sampling was planned to select the schools, stratified by urban/rural areas. However, with the ongoing Covid-19 pandemic, some secondary schools restricted their contact with external visitors. Instead, convenience sampling was applied in schools sampling. Convenience sampling

is the sampling method where researchers select those cases which are the easiest to access under given conditions, even if the sample may not be ideal (Sparkes and Smith, 2013). The sampling of schools in this study only included those who were accepting external visitors.

The two participating schools were both mixed gender and located in Hefei, Anhui Province. School 1 was situated in the urban area of Shushan District and was a non-compulsory boarding school with around 1200 students. School 2 was situated in rural area of Feixi County and was a boarding school with 400 students.

5.2 Methods of the qualitative study

5.1.1   Participants and recruitment

Participants (n=48) aged 12–15 years were selected to participate in focus groups. The sample was mixed gender (n=24 boys; n=24 girls) and there was a balance in age (n=24 students aged 12-13; n=24 students aged 14-15).

Criteria sampling (Sparkes and Smith, 2013) was used to select these participants. In criteria sampling participants are chosen because they have a particular feature or attribute. Here, the set of criteria used was: (i) students

aged between 12-13 years and 14-15 years, (ii) male and female students, and (iii) students who had high, medium, and low levels of physical activity. The data on different levels of physical activity were obtained from the self-reported physical activity data from the cross-sectional study to identify potential participants and to ensure a range of physical activity levels were represented in the participant sample. For each focus group, participants were selected from two classes in the same school grade so that there was familiarity among participants to encourage maximal discussion (Mareschal and Delaney, 2019).

In total 8 focus groups were completed across the two schools (Table 20).

5.1.2   Ethics

This study was approved by the University of Birmingham Science, Technology, Engineering and Mathematics Ethics committee at the University of Birmingham (ERN:20-0583). A parental opt-out procedure was used, and no parent opted their child out of the study. Researchers explained the study and procedures to all the students as a group and then distributed assent forms. Pseudonyms are used in the reporting of the findings.

5.1.3 Data collection

Focus groups were used for the study as they are a suitable method of qualitative data collection for the 12-17 year age group (Mareschal and Delaney, 2019). Compared with individual interviews, focus groups include groups of individuals, which can help to decrease self-consciousness (Kennedy et al., 2001). In addition, participants may be more relaxed in a collective interview which is perceived by this age group as more fun and reassuring than an individual interview (Mareschal and Delaney, 2019). Furthermore, there are advantages to conducting focus groups with adolescents who are already familiar with each other, as it can facilitate a smooth process because communication patterns are already developed among the group (Mareschal and Delaney, 2019). Another advantage of the focus group method is that it may promote more engagement; as participants exchange opinions and consider their own views in relation to others, which may encourage participants to refine their thoughts (Roller and Lavrakas, 2015). Regarding data generation, focus groups provide the possibility of multiple perspectives, which allow participants to express themselves broadly. Overall, discussion as a group prompts more elaborative responses, refined thoughts, and depth into specific topics (Sparkes and Smith, 2013).

The focus groups were organized by: (i) age; and (ii) gender. In relation to age, separate focus groups were completed for students in the 12-13 year and 14-15 year age-groups because there were likely to be developmental differences in expression and comprehension across school grade levels (Kennedy et al., 2001). Separation of age groups in this way also helped to avoid some of the potential power imbalances between higher and lower grade students and may have encouraged participants to speak without any inhibitions (Shaw et al., 2011). For each age group, separate focus groups were completed for boys and girls, as existing evidence suggests that boys and girls have different views and usage habits on social media. It has been reported that girls are more likely to focus on their emotions, feelings, and to engage more with selfies (Anderson and Jiang, 2018b), whereas boys prefer to play games and interact with friends (Ali et al., 2021). In addition, motivations for and types of physical activity may differ between boys and girls. Evidence suggests that boys tend to show preferences for team sports, whereas girls often favour rhythmic activities (Lee et al., 1999a). Moreover, there is literature reporting that boys are motivated to have a more muscular body image and girls are more likely to want a slender body image (Hallal et al., 2012; Trost et al., 2002). Also, participants with high, medium, and low intensities of weekly leisure time activity were selected for each focus group to ensure diversity in the focus groups in relation to physical activity.

Table 20 Focus groups completed in two schools

School 1 (Urban school)		School 2 (Rural school)	
Focus group 1	Girls 12-13 years old	**Focus group 5**	Girls 12-13 years old
Focus group 2	Boys 12-13 years old	**Focus group 6**	Boys 12-13 years old
Focus group 3	Girls 14-15 years old	**Focus group 7**	Girls 14-15 years old
Focus group 4	Boys 14-15 years old	**Focus group 8**	Boys 14-15 years old

5.1.4 Design and piloting of the focus group topic guide

5.1.4.1 Topic guide development

To explore the objectives, I developed the topic guide to include elicitation techniques and semi-structured questions.

The topic guide was organized into 4 sections (Appendix 4): (1) discussion of the definition of social media and use of pictures related to physical activity downloaded from social media as an 'icebreaker'; (2) participants' uses of social media, (3) participants' uses of social media in relation to physical activity; and (4) summary of discussion and opportunities for adolescents to provide further information and feedback. Sections 2-4 were the main body of the semi-

structured questions, and these aimed to allow students to interact with myself (the interviewer/facilitator) and other members of the focus group.

The semi-structured and elicitation approach to the focus groups was selected to generate discussion. For example, to encourage discussion on the definition of social media, I started with the general question: "When someone says the word "social media", what do you think of?". To generate further responses, I then changed the phrasing to ask again: "How would you describe social media (such as what does it do, what does it enable you to do?)". Finally, I extended the question further: "Do you think everyone your age would describe it in that way, and if so why or why not?" Posing questions in these different ways helped adolescents to surface and articulate their thoughts on social media. Overall, elicitation techniques are advantageous for adolescent age groups because they can help them to think and articulate their thoughts more clearly (Bagnoli, 2009). A visual method of elicitation using pictures of social media content was also used during the focus groups to support discussions. The pictures used were selected and refined according to the reflections of adolescents taking part in the pilot study, to ensure the pictures used were common and familiar to the content observed by adolescents daily.

Overall, the semi-structured design was selected to provide participants with greater control during the interview process and to provide a sufficient level of flexibility for participants to express their opinions and ideas (Sparkes and Smith, 2013). In turn it was expected that deeper knowledge about the topic could be generated than from a structured interview (Sparkes and Smith, 2013).

5.1.4.2   Pilot focus groups

Before the eight focus groups were conducted, I arranged 3 focus groups (one in the UK and two in China) with 16 participants to pilot the topic guide and develop my facilitation skills. The participants included: peer researchers based in the UK (n=4) in the first focus group and 8th grade adolescents (age 14-15 years) in China (n=12; 6 boys and 6 girls) in the remaining two focus groups.

I conducted the UK focus group in English and was observed by supervisor MP, who provided feedback following the focus group. For the remaining focus groups, twelve participants were recruited through the school taking part in the pilot study, and I conducted the focus groups in Chinese. These focus groups helped to pilot the planned techniques for generating relevant data that reflected adolescents' uses and experiences of social media overall and in relation to physical activity. Following piloting, the focus group topic guide was

refined, for example, rephrasing the questions to facilitate adolescent understanding. The pilot study data were not included in the analysis of the qualitative study.

5.1.5   Conduct of the Focus Groups

I facilitated all of the focus groups. Each group comprised 6 participants, as this group size is recommended for adolescents in this age range (Kennedy et al., 2001).

The focus groups were conducted in Chinese and took place during the school day, in the time typically reserved for extracurricular activity. Groups were held in separate, private rooms within the school and were audio-recorded. Each focus group was planned to last around 90 minutes but the length varied slightly between different groups. Adolescents of a similar age are suggested to be able to stay focused on the group task for up to 90 minutes (Kennedy et al., 2001), and thus 90 minutes was deemed an appropriate amount of time.

5.1.6   Data coding and analysis

In the data coding and analysis process, five researchers were involved. I, as the first researcher, am a 28 year-old Chinese female doctoral-level student. The second researcher (ZY) is a 29-year-old male Chinese researcher who is a doctoral student focusing on qualitative research in sociology. The three other researchers involved were my supervisors. MP and PA are mixed-methods public health researchers and qualified medical doctors, and VG is a qualitative researcher in the field of physical activity, social media, and adolescents. The benefits of a diverse group of researchers involved in data analysis are that it helps to bring rigor and objectivity to the study (Maher et al., 2018). Prior to analysis I transcribed verbatim and translated into English the first two focus group audio recordings and these were then reviewed by ZY through the checking of the transcripts alongside the recording.

An inductive thematic analysis approach was used to analyse the data (Braun and Clarke, 2006). This approach was selected because the analysis process is driven by the dataset and not bound to a pre-existing theoretical orientation, nor is its goal necessarily to generate new theories like other approaches, such as grounded theory (Braun and Clarke, 2006). Thematic analysis can be utilised to explore the perspectives of different research participants, similarities and differences between participants and differing groups, and to generate

unexpected insights (Braun and Clarke, 2006). In this study, the analytical approach followed Braun and Clarke's (2006) 6 step process for thematic analysis.

The first step of familiarisation was conducted by ZY and myself, who read each of the 8 transcripts carefully, noting down initial ideas developed from the transcripts. In the second step, I started to develop a list of codes in NVivo12, and this was informed by the familiarization process. In this step, ZY and I reviewed the code list. We met regularly to discuss and agree on codes, adopting a flexible and organic approach where the codes assigned to the data set were tweaked to minimise replication or codes were expanded or collapsed to accommodate the developing ideas from the coding process. As a further layer of interpretation in the coding process, two of the richest transcripts were translated into English and reviewed and discussed with MP, PA, and VG, and the codes were then refined accordingly. This process helped to ensure that the analysis was in keeping with the wider research questions and aims of the thesis. An example of how this review process worked is as follows: I and ZY had used the separate codes 'Expand communication' and 'For both sides to contact'. Through discussion of the meaning of the codes with MP, we agreed there was significant overlap, and they could be integrated into one code.

Following refinement of the codes after discussion with the wider team, I applied the codes to the remaining 6 transcripts.

The third step involved developing themes. In this step, I independently began to cluster the codes to identify higher level patterns in the data set. I collated codes into potential themes, gathering all data relevant to each potential theme. ZY helped to check clustered codes and potential themes. Then I checked all the codes and categories again and these were further developed during discussions with ZY which further shaped potential themes. A draft document outlining the organisation of codes into categories and development of potential themes was reviewed by MP, PA, and VG. For example, when ZY and I started to develop themes, we initially used advantages and disadvantages as a framework to organise the potential themes. Following this and through review and discussion with VG, a conceptual framing of the themes was pursued to illustrate the complexity and wholeness of the data.

The fourth step involved reviewing the themes. I developed a thematic map to help organise codes and categories, and review relationships between them to check that these were intuitive. Together with ZY, we discussed and amended the thematic map. The whole process was iterative to make sure the expression of the whole dataset could be concise and precise. These categories within the

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thematic maps were reviewed and interpreted to review and refine initial themes and identify subthemes.

The fifth step involved defining and naming themes. I met with ZY to discuss and refine the initial themes and subthemes. If different ideas occurred, themes or subthemes would be marked and discussed again, and redundant themes were either removed or merged with other themes. Once themes and subthemes were established, we identified the themes and subthemes evident in each transcript. Iterative analysis and discussion to refine the specifics of each theme and the analysis process was ensured to be logical, generating clear definitions and names for each theme, subtheme, and category.

An example of the process of how the themes were generated is shown in Table 21.

Table 21 An illustration of the process of theme development

Example Data	Codes	Categories	Themes
It is best if there are people who comment below the post. Those people may have practiced the content in the video themselves, and then discuss in the comment area to prove that the exercise is fruitful.	Communication and interaction in posts	Interactions with social media posts	Interactions on social media push forward the PA involvement
You can comment something under the posting, and then a lot of people can interact and exchange the experience of the movement.	Endorsements and support from reviews	Endorsements by audiences	
I saw my idol on Weibo, I forgot when, and then he posted a picture of himself playing basketball, that is so handsome, and then I would have the urge to learn to play basketball too.	Impacts from celebrities; Celebrity endorsement	Encouragement from celebrities	
In fact, this ranking will make you feel that there will be a sense of competition, that is, if some friends' ranking is suddenly above me today, they may want to catch up with him tomorrow.	PA challenges; Stimulates the idea of competition; Ranking and likes in WeChat Sport	Competition on social media	
The ranking of the number of runs in WeChat sports can further stimulate people's competitiveness, and then promote people's exercise	The clear effects shown by the surrounding people; Showing off PA achievements;	Share their PA achievements on social media	
Those sports videos on social media are subconsciously changing me, making me like sports, it is not the kind of mandatory telling me what to do, but it will slowly change me subconsciously.	Abundant sports resources; Different knowledge of PA; Active encouragement and promotion; More cost-effective; Repeated viewing possibilities	(Pros) Abundant resource (Pros) Suggested content related to PA (Pros) Convenience	Accessibility of social media, making sure that various PA resources could be seen and disseminated on social media, but rich PA resources are also problematic
There are a lot of videos on social media that are very good for sports. You may be very resistant to seeing sports, but after being exposed to something from social media, you think you can try it, and then you will gradually become willing to try sports.			
I think the advantage is that it can better promote us to exercise. For example, we don't need to ask a professional coach to teach us these things, which saves money.			

It looks good to have that kind of title, but it doesn't work. Bloggers have no real skills themselves, and what they teach may be unprofessional. The disadvantage of being online is the continuity, as she just said, sometimes if you learn fast, if these videos are not updated all the time, you may not pay much attention to this. When you see a post about sports, you want to do some activity. Then sometimes we may brush to other entertainment activities, for example, sometimes brush to play games or something, and then indulge in this game again.	Other interesting content distracts from PA; Hard to insist doing PA; Not being able to learn systematically; Unreliable content	(Cons) Lack of interest and motivation (Cons) Content of low credibility; (Cons) Distract by other interesting content on social media;	
Because the teacher wanted to urge everyone to check in for sports in the group during the pandemic, the teacher encouraged you to take a video and post it in the group, and social media is like a CCTV monitoring you. The fact is that my mother was taking pictures or videos with her phone when I was jumping the rope. I still remember that the teacher appealed to everyone to do PA check-in with the group during our winter vacation.	Supervision and support on PA from parents; Supervision and support on PA from schools	Social media play a role in supervision	Supervision from parents and school teachers on social media and in-site foster PA engagement

Note: PA = physical activity

5.1.7 Rigour

Rigour of this qualitative study was informed by the eight criteria outlined by Tracy (2010), and included: (a) worthy topic, (b) rich rigour, (c) sincerity, (d) credibility, (e) resonance, (f) significant contribution, (g) ethics, and (h) meaningful coherence. This relativist approach to rigour drew on the principles of quality, validity and generalizability presented by Smith and McGannon (2017).

In terms of worthiness of the topic, adolescents' social media use and social media use in relation to physical activity is an original focus that lacks an existing robust evidence-base, particularly in the target population of Chinese adolescents.

With regards to sincerity, pilot focus groups were conducted before the main focus groups, to help develop and refine the focus group plans. For the two pilot focus groups with Chinese adolescents, I summarized the transcripts and initial codes and presented these to VG, MP, and PA to check and ask for feedback, to ensure the whole process of focus group data collection was reasonable and the content meaningful. From the pilot study, all researchers worked together closely and collaborated; any steps of the work, including translation and transcripts, were completed by at least two researchers. Self-reflexivity went through the analysis and data collection process to help improve and refine the analysis. After each group, I reviewed the shortcomings of the focus group conduct and identified strategies to refine for the next focus group.

Regarding credibility, the interpretation of data from the focus groups showed traits of multi-directory and penetrative vertically. The social media use and social media use in relation to physical activity were discussed in detail in the focus groups. I used conceptual themes to interpret themes organically,

combining data relating to social media use generally and its use in relation to physical activity. I also presented and summarized the variation between different groups (gender, age, and rural & urban) to ensure the richness and thickness of the study. As this is the first qualitative study I have conducted and analysed, the limitation of my knowledge cannot be ignored. However, involvement of my supervisors and the second researcher has ensured rigour in the process.

Regarding rich rigour, a diverse sample was selected to include participants from different genders and age groups. These groups were separated during data collection to encourage discussion and generate in-depth data. Sampling of the schools included both urban and rural areas and boarding and non-boarding schools to balance the different characteristics of schools. The target population was Chinese adolescents, which is population of interest, as the social media ecology in China is unique, and adolescents' uses of social media has increased substantially in the last decade. The data collection and analysis approach followed an established and evidence-based thematic analysis method (Braun and Clarke, 2006).

Regarding meaningful coherence, I developed the research questions based on the current literature and designed this qualitative study to address the

research questions. Regarding the overall conduct of the study, I followed the planned study design and adjusted it when required and in discussion with my supervisors. For example, I adjusted data collection approaches and techniques used in the analysis process. Finally, this study meaningfully interconnects literature, research questions, findings, and interpretations. The research questions are about adolescents' social media use and social media use in relation to physical activity, and findings show multi-dimensional aspects of social media use among Chinese adolescents and how these are associated with use in relation to physical activity. The findings are presented in relation to the Chinese context.

5.3 Qualitative findings

5.3.1 General social media use

In this study, adolescents' uses of social media were broadly similar to previous literature (see Chapter 1). Many of the adolescents were inclined to engage with others' postings on social media timelines/news feeds and/or from suggested content on search pages. This browsing behavior provided opportunities for the adolescents to understand others' lives, read about topics of interest, and acquire news updates. For these adolescents, interactions and communication with public celebrities could co-exist with browsing whereby

adolescents observed the posts of celebrities. Some of the adolescents created

and shared social media posts. For these adolescents they were the 'main

characters on the social media 'stage', making their own videos, expressing

their own ideas, commenting, or liking others' posts.

> You can learn about other people's lives by reading other people's posts on social media,
> and you can also find out what interesting things your friends have done, and keep up
> with the trend, in case you don't know what your classmates are talking about, in that
> case, you seem to be excluded some communities (FG7, Girl 6, age 14-15, school 2).

> After spending a long time making a video through my own efforts, I posted it to share
> with everyone, and I felt a special sense of achievement (FG6, Boy 6, age 12-13, school
> 2).

Overall, and building on prior literature, three key features of adolescents'

engagements with social media were apparent in the data set: (i) enriching

after-school life; (ii) parental concerns; and (iii) privacy. Together these three

features exemplify the complexity of how adolescents engage with social media.

5.3.1.1   Enriching after school life

Social media has a number of functions that enabled this medium to

operate as a form of entertainment for the adolescents in this study. For

instance, one of the main Chinese social media sites Weibo[4] includes

functions that support live stream videos/broadcasts, live chat and

discussions focused on specific topics. The adolescents described how

they used these social media functions for entertainment purposes after

school. In particular, playing games and watching short videos were the

most entertaining aspects of social media use mentioned by the

adolescents. For example:

Boys seem to regard playing games as a part of their life, they seem to always play games

all the time and feel that games are very important. Playing games for girls to kill time or

to entertain (FG7, Girl 1, age 14-15, school 2).

Many people probably use it [social media] for entertainment. After finishing homework

or tasks, they will use this method to have fun, often swiping Douyin[5] for an hour (FG2,

Boy 2, age 12-13, school 1).

I play Weibo mainly because it is fun, because I can know different people and different

things about it, and they [social media friends] will share some of their daily life. I think

social media is very interesting and enriches my life (FG1, Girl 4, age 12-13, school 1)

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[4] Weibo is a social media website launched by Sina.com that provides microblogs. Users can publish news through web pages, mobile phone programs, etc., and upload pictures and videos or live video to achieve instant sharing and dissemination of interaction. Currently, it's called the Chinese version of Twitter

[5] Douyin is the Chinese version of Tiktok, a short-video social app that can be viewed on smartphones

> Watching the live broadcast of the blogger, and then someone commenting in real time, or we can buy things directly in the live broadcast room (FG4, Boy 3, age 14-15, school 1).

Idol chasing was also a key way in which the adolescents engaged with social media after school. In Chinese culture, idol chasing is prevalent in the adolescent population and refers to worshiping idols. In the context of social media, idol chasing involves following news about celebrities via different social media platforms, following the celebrities' accounts and pressing likes for the posts that relate to celebrities. The adolescents in this study claimed that the gap between celebrities and the adolescents was reduced through social media, and that they felt close to and a sense of connection with celebrities. These feelings of connection were attributed to how the celebrities used social media to openly share aspects of their daily routines and life experiences.

> On some social media platforms, you can learn about the latest developments of the star, such as what live shows or series he is going to release, as well as his schedule. You can watch it on social media in [real] time because if there is no such platform, you can only rely on TV by chance (FG5, Girl 6, age 12-13, school 2).

> I saw a young lady who went to Wuhan to support the epidemic, and then she posted on Weibo said, "Wang Yibo (a celebrity) please wait for me to come back", and after she

came back, Wang Yibo indeed made a bowl of noodles for this young lady and this young

lady posted it on Weibo (FG1, Girl 2, age 12-13, school 1).

5.3.1.2   Parental concerns

The majority of the adolescent participants reported that their parents were

concerned about their uses of social media and some parents imposed rules to

control social media use. Parental concerns mainly related to the potential of

social media use to: negatively impact school study, foster the development of

poor and/or anti-social behaviours (e.g. spreading rumours, cyberbullying,

posting unrealistic images of the body and/or engaging with false information,

pornography and gambling), increase opportunities to be in contact with people

who have the potential to cause distress or harm, and/or contribute to poor

physical (e.g. short eyesight, fatigue) and mental health (e.g. anxiety). For

example, adolescents reported on their parents' concerns in the following ways:

Playing social media can cause vision loss (FG5, Girl 4, age 12-13, school 2).

Some adults are more worried about their children playing games, because that kind of
game, for example, the glory of the king, once the game starts, once the game starts, it
lasts for at least one hour delaying the time for homework and study (FG7, Girl 4, age
14-15, school 2).

When we may have the possibility to be deceived when meeting social media friends. Also, there are people who go online to date and get scammed (FG1, Girl 3, age 12-13, school 1).

Parents were concerned about adolescents being more exposed to negative elements, such as information or people on social media which they would not be easily exposed to offline. In the 'real world', the study and life of adolescents are typically set according to standards set by schools and parents. On social media, adolescents' degrees of freedom are magnified, with limited restrictions from schools and parents. For example, adolescents may experience early encounters with certain content or people. In turn, the age adolescents begin to use social media was reported as a key parental concern.

The reason my parents were worried about me using social media was because they were afraid of if I would have puppy love (FG4, Boy 2, age 14-15, school 1).

Our parents are of the older generation, and they think in a more conservative way. They deem it's not much value to use phones and social media, study is the right thing to do (FG6, Boy1, age 12-13, school 2).

Social media itself is good, but some adolescents may learn bad things on social media, such as swearing, uncivilized language (FG2, Boy 6, age 12-13, school 1).

Despite parents' concerns about social media, some parents were supportive of how it could be used to communicate with their children. For example, parents could use social media to video call their children to make sure their children were safe:

> Social media has the role of supervision. Now with QQ and WeChat, my mother said that when I got home, give her a video call and let her see if I am safe at home (FG7, Girl 4, age 14-15, school 2).

> Sometimes I go out to play with my brother or classmates on weekends, and then my mother will remind me to bring my mobile phone to communicate with my mother, and my mother also reminds me to use social media to report have I arrived home safely (FG 1, Girl 1, age 12-13, school 1).

5.3.1.3   Privacy

Social media is an attractive medium to adolescents because they can freely express their ideas and perspectives. Adolescents reported that they feel more relaxed if they express their feelings on social media when compared to talking to someone face-to-face. Some adolescents used multiple social media accounts to protect their privacy, and to enable them to express their ideas freely.

> Sometimes, for example, when I am in a bad mood, I will go to social media to express myself. Anyway, they don't know me, and then I say something, and then I have no scruples (FG2, Boy 4, age 12-13, school 1).

> I have two QQ accounts, and I don't post very often on the main account. Sometimes when I'm in a bad mood, I often post some posts and then delete these posts on my main account. Whereas if my complaints posted on another account that means no one will notice (FG3, Girl 1, age 14-15, school 1).

The perception that privacy could be 'leaked' was a concern to adolescents. Although the adolescents found ways to protect their privacy (e.g., have extra accounts, block users), mutual social media friends were inevitable, and, in turn, some content posted on social media could be noticed and found.

> But there is also a downside to telling secrets to others on QQ, that is, others may tell my mother and violate my privacy (FG1, Girl 5, age 12-13, school 1).

> But social media also has shortcomings. For example, your usual privacy is easy to be leaked and exposed (FG7, Girl 2, age 14-15, school 2).

In this section, key features of adolescents' engagements with social media included: enriching after-school life, parental concerns, and privacy. These features highlight the complexity of how adolescents engage with social media and the ongoing struggles that they experience between how to maximise the benefits from using social media while mitigating potential risks. Adolescents' reports of how they use social media illustrate that many adolescents are highly competent users of different social media spaces, seen through their negotiations between the blurring boundaries of online and offline worlds, public and private spaces and experiences of autonomy and control. In the following sub-sections, how these engagements with social media use are apparent in the ways in which adolescents engage with physical activity are reported.

5.3.2   Conceptual Themes (related to physical activity)

In this study, I found that adolescents could use social media to achieve different tasks and activities in their lives related to physical activity. It was apparent in the data set

that social media: helped to ensure that various resources and knowledge related to physical activity could be accessed; was a good platform to discuss content related to physical activity; supported the sharing of achievements related to physical activity; and helped to supervise the completion of physical activity. These tasks and activities of social media use are reported in three conceptual themes that show how social media use informs adolescents' engagement with physical activity: (i) interaction, (ii) accessibility, and (iii) supervision.

5.3.2.1   Interaction

In relation to physical activity, social media provides opportunities for interactions relating to competition and the encouragement of physical activity behaviours. Adolescents could compete with their social media friends and be encouraged to engage with physical activity by celebrities. Furthermore, adolescents could access sport-related content from social media that increased their understanding of sports through further discussion with others on social media. Meanwhile, positive interactions such as showing one's physical activity performance on social media also encouraged adolescents to do more physical activity. These key features of interactions through social media will be explored in this sub-section.

5.3.2.1.1   Competition on social media

As mentioned earlier, social media can play a role in helping adolescents to understand and engage with others' lives. WeChat Sports is a program contained in WeChat that provides opportunities to record physical activity by recording the number of steps completed per day. Through this function, every night adolescents could see

their rank in the number of steps completed per day compared with others. For some adolescents, this monitoring of step count induced an element of competition through social media. Moreover, some activities arose on social media, such as physical activity challenges (e.g. The physical activity challenge launched by fitness bloggers on Douyin), and sports check-in relays (e.g. WeChat Sports[6] Daily Check-in), that inspired some adolescents.

> I use WeChat Sport. Every day I see how many steps I can take and how many rankings I can rank. I want to be the first, and I have a mentality of wanting to compete with others (FG6, Boy 6, age 12-13, school 2).

> There is also virtual fitness. I exercise and clock in with some fitness bloggers, and competed with audiences online. During the pandemic, I gained weight. At that time, I swiped a video of weight-loss exercises at home. I forwarded it to my mother, and then my mother forwarded it to my aunt, my aunt asked my cousin and me to follow the live stream and exercise together, and then my cousin persisted, but I am hard to persist in doing this (FG1, Girl 5, age 12-13, school 1).

Social media was an open platform; adolescents could post their messages, videos and images anytime. In turn, it was a useful platform to share their physical activity achievements, such as showing some photos or videos of their physical activity learning or practice. By sharing their physical activity achievement, they were more confident in physical activity and because of that they were more driven to engage with physical activity. In addition, sharing physical activity achievements on social

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[6] WeChat Sports is a public account similar to a step-counting database developed by Tencent. Users can check the number of steps they take every day by following the WeChat Sports Official Account, and they can also compare it with other users, or press likes to other users

media prompted interaction with interested others, who would comment or like on posts.

> Sometimes when I run, the screenshot of the step count will be posted to the QQ feed, and I will feel proud when I feel like showing off (FG6, Boy 4, age 12-13, school 2).

> And social media also provides you with a platform, you can post it for more people to see, and then everyone thinks you are cool (FG2, Boy 3, age 12-13, school 1).

5.3.2.1.2   Sense of community

Peer encouragement through social media related to physical activity influenced how adolescents felt about their bodies and/or engaged with physical activity. Content about physical activity or healthy lifestyles shared by their social media friends made some adolescents feel that they should change their health-related behaviours and want to have the same figure or achievements as the person who posted this content. On the other hand, adolescents also sought cooperation on social media. For example, social media provided a means for adolescents to do exercise together with peers especially when one of their friends wanted to give up or pause.

> I think it [social media] will have a certain encouragement relationship, because if one of the two people doesn't want to do it, and the other wants to continue, then that one will pull me to do it together (FG3, Girl 3, age 14-15, school 1).

> I didn't exercise myself before, and then I saw that others were exercising on social media, and there was a feeling that everyone else was exercising, why should I sit here and so on, forming a feeling of following the trend (FG8, Boy 1, age 14-15, school 2).

Adolescents gained encouragement from celebrities, especially the content posted by the celebrities that they idolised. Social media offered a glimpse into the lives of celebrities. For example, some celebrities commenced new sports and this could make their fans interested in that sport. Due to the specificity of sports stars, they not only can encourage adolescents to engage with physical activity but also set a positive and inspiring example for more adolescents to engage in physical activity.

> I think there are many stars playing basketball. For example, Kobe Bryant passed away, but Kobe's Mamba spirit has always lived on in the world, and it has inspired generations of teenagers who are willing to do these basketball sports. (FG5, Girl 1, age 12-13, school 2).

> I saw my idol on Weibo, I forgot when, and then he posted a picture of himself playing basketball, that is so handsome, and then I would have the urge to learn to play basketball too (FG 1, Girl 6, aged 12-13, school 1).

Meanwhile, endorsements by audiences increased the credibility of some physical activity content. Adolescents explained that the posts with more endorsements, especially the long and sincere comments, added a form of re-enforcement to engage with physical activity.

> There must be people who comment below, and then there are many people who support it, and you can see that everyone in the audience can personally experience it. The kind that everyone shares with success stories (FG1, Girl 5, age 12-13, school 1).

Interactions with social media posts had the potential to deeply engage adolescents with physical activity. It was evident in the data set that adolescents perceived that social media could be used to disseminate and show information on how to engage with physical activity. For example, in the comments, adolescents could communicate their ideas about physical activity, and they were free to express their experiences of

physical activity. Gradually, communications on the posts with the original post together consisted of an organic whole to show the overall physical activity experience.

> You can comment something under the posting, and then a lot of people can interact and exchange the experience of the movement (FG4, Boy 4, age 14-15, school 1).

> Go to communicate with other athletes on the Internet, how to exercise, and promote our exercise, they may record their exercise methods, we can follow and learn (FG8, Boy 4, age 14-15, school 2).

In this section, the interaction of adolescents using social media in relation to physical activity included: competition on social media and communications on posts. Adolescents used social media to help them be more engaged with physical activity, and those kinds of interactions worked organically and coherently to ensure physical activity-related content could be shown in front of adolescents. Social media provides a platform for adolescents to create an enthusiastic atmosphere to discuss physical activity-related content and show physical activity-related achievements. Adolescents also increased physical activity engagement through encouraging each other or from the effects of engaging with celebrities' posts.

5.3.2.2   Accessibility

Accessibility refers to how social media provides a platform for adolescents to locate relevant information related to physical activity in a timely manner. Accessibility supports the notion that many resources related to physical activity are available through social media, for example, information on different physical activity pursuits.

5.3.2.2.1 Social media provides physical activity learning opportunities

Social media supports the mass sharing of content. Many physical activity resources could be shared on social media, and adolescents could watch them at anytime and anywhere when they turn on their phone or tablet, which unwittingly increased the possibility of physical activity exposure. On the other hand, because of the emphasis on adolescents' physical activity from the government[7], many social media platforms responded to the government call and were reported to be actively encouraging adolescent physical activity participation.

> There are a lot of videos on social media that are very good for sports. You may be very resistant to do sports, but after being exposed to something from social media, you think you can try it, and then you will gradually become willing to try sports (FG3, Girl 3, age 14-15, school 1).

> Social media itself may provide a very rich material for everyone, maybe play tennis, we didn't know how to play tennis at first, but I saw people teaching tennis above, I may want to go tomorrow, I want to try something I haven't tried exercise (FG1, Girl 1, age 12-13, school 1).

More formats of physical activity resources prevailed in social media, such as videos, pictures, and GIFs, satisfying the diverse interests in physical activity learning. In terms of the content of physical activity, social media offers more practical physical activity tips and more efficient ways of engaging with physical activity, all of which provide new ideas for adolescents. When adolescents receive physical activity recommendations from social media, the suggested content included content that was tailored to their

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[7] Chinese Ministry of Education calls for adolescents to keep 1-hour physical activity every day. http://www.gov.cn/gongbao/content/2007/content_663655.htm

preferences and interests. Meanwhile, social media has given adolescents a wider range of choices. On social media, adolescents could select content related to physical activity according to their preferences and interests.

> It is positive. For example, a certain physical activity dissemination can be combined with social media, it can be promoted for more visibility. In that case, it can bring us some inspiration and gains in sports (FG 3, Girl E, aged 14-15, school 1)

> Social media itself may provide a very rich material for everyone, maybe play tennis, we didn't know how to play tennis at first, but I saw people teaching tennis in social media, I may want to go tomorrow, I want to try something I haven't tried exercise (FG1, Girl 1, age 12-13, school 1).

> For example, in terms of how to play table tennis, social media will tell you more skills that you can't learn normally (FG4, Boy 3, aged 14-15, school 1)

> Recently, I also usually binge a lot of dancing videos on QQ, such as Wang Chongmo (A dancer) and his dance partner. Because I can dance Latin dance, I always pay more attention or search for related information (FG 4, Boy 1, aged 14-15, school 1)

The resources about physical activity on social media varied and this approach to learning about physical activity was also convenient. Firstly, exercise teaching on social media was cost-effective, adolescents did not need to go to the gym or a specific court to engage with physical activity, nor did they need to pay for membership fees. Repeated viewing is another affordance of social media that influenced engagement with social media content related to physical activity. The majority of the content accessed from social media could be viewed multiple times.

I think the advantage is that it can better promote us to exercise. For example, we don't need to ask a professional coach to teach us these things, which saves money (FG4, Boy 5, age 14-15, school 1).

Some key parts of the exercise video can be watched repeatedly, which allows us to exercise more effectively. For example, if you haven't learned a detail, you can watch it again and again (FG6, Boy 2, age 12-13, school 2).

5.3.2.2.2   Social media provides physical activity learning pitfalls

The adolescents reported that there were many resources on social media related to physical activity, but many contents did not support their interests and/or were not perceived to be motivating. Some adolescents complained that lots of materials took time to see the effect on weight and body shapes and this resulted in easily giving up on the suggested activities. Moreover, many adolescents suggested that they would save or bookmark sports videos without actually engaging with the activities. In terms of format, too many words and boring content also limited the influence of social media content on adolescents' physical activity behaviours. Social media also provided various information and resources, that distracted adolescents' attention from physical activity. Games, entertainment gossip and chatting apps, etc. were suggested to limit adolescents' focus on physical activity, even if they were watching the physical activity learning resources.

The disadvantage is that some movements may be difficult to learn for a while, and it takes a lot of time and energy, but it may not be learned, and then people may feel frustrated (FG6, Boy 2, age 12-13, school 2).

> When you see a post about sports, you want to do some activity. Then sometimes we may brush to other entertainment activities, for example, sometimes brush to play games or something, and then indulge in this game again (FG2, Boy 3, age 12-13, school 1).

Content of low credibility was also a key factor. Content that was perceived to be unreliable and exaggerated – such as a blogger's poor body and performance – limited adolescents' perceptions of credible physical activity content. Lack of focused/structured content was another problem. In offline contexts, learning about a new sport is often achieved through traditional lesson arrangements and the sequencing of learning step by step. Furthermore, in offline contexts learners can ask questions and gain help from coaches in real time. According to adolescents, social media could not achieve that. Some bloggers may not always update information in time and the arrangement of teaching was not always reasonable to gain support and advice, with most content directed to a vast and diverse audience, and not tailored to specific demographic or individual needs.

> It looks good to have that kind of title, but it doesn't work. Bloggers have no real skills themselves, and what they teach may be unprofessional (FG4, Boy 1, age 14-15, school 1).

> For example, there are some content that you don't understand, but you can't communicate with the people in the video. And sometimes learning is not very systematic, some I can learn, some I can't, and I don't know what to do (FG2, Boy 4, age 12-13, school 1).

Considering these inevitable drawbacks, a preference for group exercise offline was mentioned by adolescents. In schools, physical activity was always organized in the unit of a class or a grade, and adolescents perceived this structure to support their

engagement with physical activity. Furthermore, the quality of teaching was perceived to be greater in classes, as social media physical activity resources were scattered and non-focused. Normally, learning resources for physical activity on social media were run by different bloggers, which may result in issues with quality and consistency, and qualifications may not be guaranteed. In contrast, on-site teaching (physical education class or physical activity extra-curricular activities) provides clear and structured guidance and activities: including, a warm-up, explanations, and personal suggestions. All of these may not be satisfied through physical activity learning on social media.

> Because everyone, we run and exercise from one class to another, everyone shouts slogans together, there will be that kind of atmosphere, I will feel very inspirational (FG1, Girl 4, age 12-13, school 1).

> For the safety of our sports, the school may let everyone warm up first (FG2, Boy 3, age 12-13, school 1).

In this section, the accessibility of social media indicates that more physical activity resources can be learned and disseminated through social media. Furthermore, cost-effectiveness ensures the learning could be more flexible. Though lack of interest/motivation, lack of focused/structured content, content of low credibility, and other interesting content on social media distract adolescents' attention from physical activity. However, the shortcomings of social media on physical activity accessibility prompt adolescents to prefer the on-site way to engage with physical activity, where team exercise and systematic teaching address these social media-related shortcomings. The following sub-section will show how social media helps supervise physical activity as a real-time tool.

5.3.2.3   Supervision

Supervision refers to social media as a real-time communication tool that can be used to supervise adolescents' physical activity behaviours by teachers and parents. At the same time, some adolescents perceived that more traditional forms of physical activity supervision (e.g., schools, parents) were considered to be more effective compared with supervision on social media.

There was evidence that social media could be used by teachers to supervise physical activity participation of class pupils. This was particularly evident during the pandemic and within the context of the Chinese government's emphasis on physical activity and the requirement of 1-hour exercise per day. Physical activity clock-in was widely applied in schools using social media. For example, adolescents posted or clocked-in using a class WeChat group, and their physical activity could be seen by everyone in the group.

> Because the teacher wanted to urge everyone to check in for sports in the group during the pandemic, the teacher encouraged you to take a video and post it in the group, and social media is like a CCTV monitoring you. The fact is that my mother was taking pictures or videos with her phone when I was jumping the rope (FG5, Girl 2, aged 12-13, school 1).

Except for the social media supervision of physical activity, schools and parents could provide more physical activity supervision and support offline. Adolescents claimed that practising physical activity using content accessed from social media mainly depended on spontaneity, whereas engaging with physical activity in schools or at home often involved more structure and supervision from teachers and parents. An

advantage of engaging with physical activity in more traditional ways at school and home was that teachers and parents could provide supervision such as feedback and guidance in 'real time'.

> I think schools and parents are more able to ensure the completion of physical activity. For example, like those videos you swipe from social media, sometimes it is difficult to actually take action when you just think about it in your heart. But it is mandatory for parents and schools, so you can take the initiative to exercise, that is, you can get better outcomes (FG8, Boy 5, age 14-15, school 2).

> My dad would post some pictures on WeChat Moment of his morning run, when he arrived at a destination and then they would take a picture to represent him coming here and then there might be some comments in the posting, sometimes my dad would take me running with him, and I would be happy to do physical activity with my dad (FG7, Girl 3, age 14-15, school 2)

In summary, due to the real-time trait, physical activity supervision could easily be achieved through physical activity check-in and posts of physical activity images and videos, though physical activity supervision may be more effective and feasible on-site.

The codebook and complete theme table of the focus group data are presented in Appendices 5, 6 and 7.

5.3.3 Demographic variation

I conducted the focus groups with groups of different ages and genders. During data analysis, it became apparent that there were differences in participant responses between the groups, and that differences existed by gender and age. Accordingly, an additional layer of analysis was completed to explore the variations in social media use and social media use in relation to physical activity by gender and age. Figures 11 and 12 provide an overview of the findings and these are then discussed by gender and age.

Figure 11 Variations of codes by gender

Figure 12 Variations of codes by age
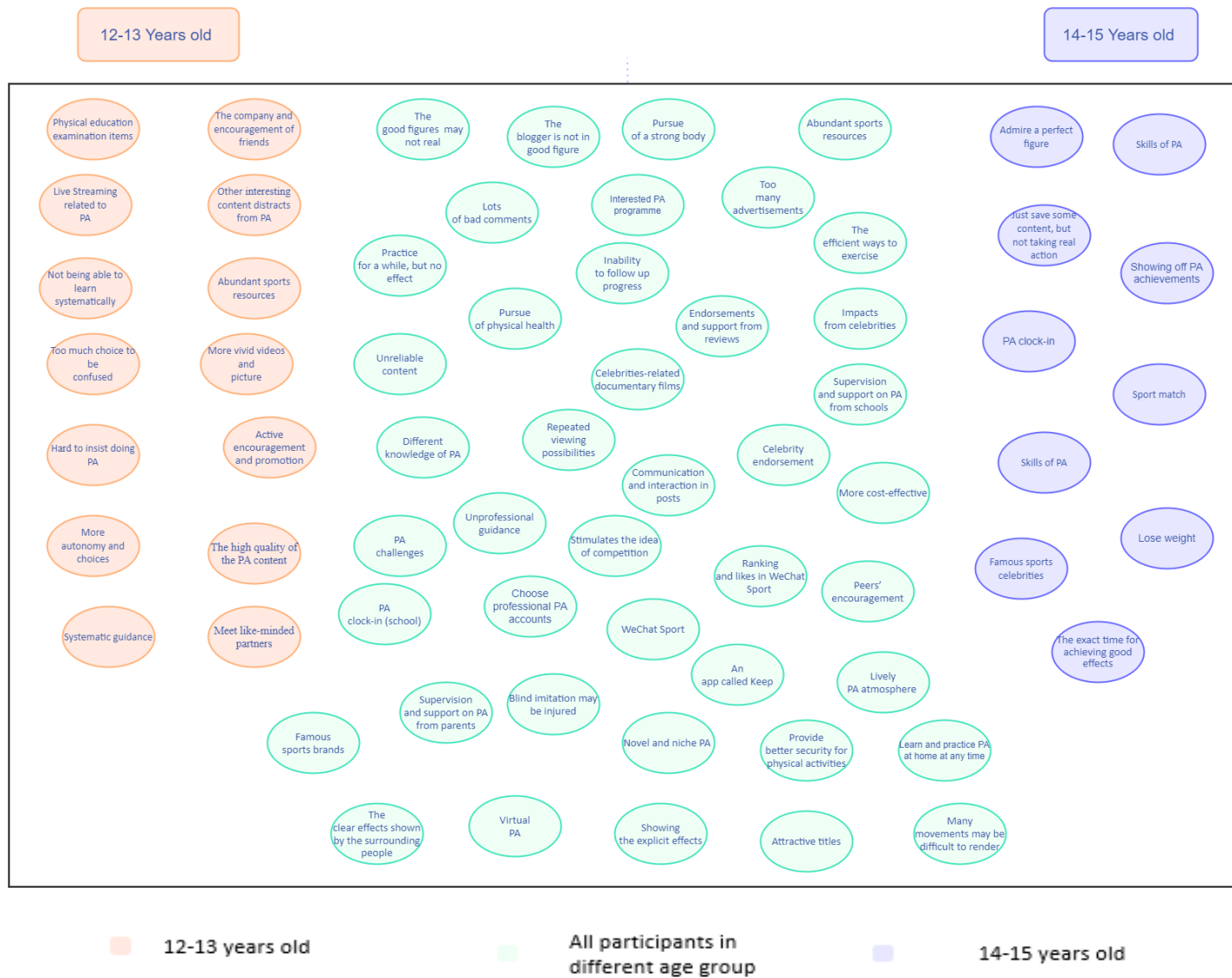
5.3.3.1   Variations in social media use by gender

In terms of social media use, there are two main differences between boys and girls. Firstly, there are differences in after-school use, generally girls preferred to chase idols, chat about gossip, and date online. Girls tended to focus on the moments of celebrities and internet influencers. In contrast, boys were more inclined to play games and watch funny videos. Boys liked to learn something new and focus on the news on social media. Privacy is another key point of difference: girls were more likely to have extra accounts due to privacy considerations.

Regarding social media use and physical activity, attitudes towards interactions on social media in relation to physical activity varied for boys and girls. Generally, girls were happy to look at their peers' performance and show their achievements of physical activity on social media, but boys concentrated more on competitive activities on social media (WeChat Sports ranking). In the mechanisms for motivating physical activity, girls were encouraged by celebrities that they favored, but boys tended to be motivated by sports celebrities and sports games and matches. In terms of the accessibility of physical activity content on social media, girls were likely to choose content that could bring the explicit and obvious effects after exercise, whereas boys were keen to choose professional and reliable bloggers accounts to learn and follow.

5.3.3.2   Variations in social media use by age

There was also variation in general social media use across the 12-13 year-old and 14-15 year-old age groups. 12-13 year-old adolescents were more likely to consume content, whereas 14-15 year-old adolescents were more likely to produce and post

content. Younger adolescents were more likely to be connected or social on social media, such as making friends, pressing likes for others' posts and focusing on the moments of celebrities and Internet celebrities. But older adolescents were more inclined to have their own autonomy and ideas in the use of social media, such as using it as an educational tool, expressing freely their own feelings, and understanding the outside world.

In terms of social media use in relation to physical activity, this differs on social media between younger and older adolescents with regard to accessibility. Younger participants were more inclined to access content related to physical activity as part of The Academic Test for Junior High School Students[8] and live commerce about sports products showed by Internet celebrities. They were also more likely to be concerned about the quality of the sports video (lengths, contents, color, special effects, and so on). Older participants preferred to watch content containing exercise skills, and the visible and obvious effects after practice. Younger adolescents showed skepticism when using those resources, they worried about no systematic learning in physical activity on social media, and discussed that it was easy to get distracted when engaging with social media physical activity content. Older adolescents were more focused on good body figures, thus they showed positive engagement in physical activity on social media.

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[8] The Academic Test for Junior High School Students is the name given to the examination for graduation and promotion after nine years of compulsory education in China. The subjects include language, mathematics, English, physics, chemistry, history, biology, geography, physical education, information technology, spoken English and science laboratory operations.

5.4 Discussion of the qualitative study
5.4.1 General social media use

This study adopted a qualitative approach to explore how Chinese adolescents use social media and how they use social media in relation to physical activity. Data collection focused on: the types of social media content that adolescents access, the influences of different social media content on adolescents' attitudes, knowledge and/or behaviours related to physical activity, and the risks and opportunities that adolescents report in relation to their uses of social media for their physical activity engagement. New evidence is provided on: (i) how Chinese adolescents use social media; (ii) how social media use influences physical activity engagement; and (iii) variations of social media use in relation to physical activity among different groups (i.e., age and gender).

It has previously been reported that adolescents use social media as a form of entertainment (Throuvala et al., 2019; Whiting and Williams, 2013). For example, they use social media to play games (Anderson and Jiang, 2018a), watch short videos (Marengo et al., 2022) and follow celebrities (Chan et al., 2013). These uses of social media were evident in this study of the Chinese adolescent population. Another similarity was related to privacy. It was evident in this study that Chinese adolescents were concerned about their privacy, and for some, they created additional social media accounts. Adolescent concerns about privacy also align with prior research that shows that adolescents anonymize key information about themselves when they use social media to protect their privacy (boyd, 2007; Kevin and Dale, 2006; Throuvala et al., 2019). Finally, the Chinese adolescents in this study had similar worries related to how

they used social media, that in line with the key trends reported in international research literature, and these included: mental health (Ghai et al., 2022), unsuitable behaviours (e.g., sexual activity, substance abuse, over drinking or violence) (Moreno et al., 2009; Subrahmanyam and Šmahel, 2011) and impacts on physical health, such as back and neck pain and vision problems (Aziz et al., 2021).

5.4.2   Social media use in relation to physical activity

Conceptual themes that identified and explained relationships between social media use and physical activity engagement included interactions, accessibility and supervision. In relation to interactions, this theme covered two sub-themes, that showed how both competition and a sense a community supported physical activity engagement. According to the adolescents in this study, a form of competition engaged with via WeChat Sports heightened adolescents' desire to win, and in turn, this enhanced their engagement in physical activity. In connection with this, a sense of community brought adolescents more opportunities to learn, interact with each other, find celebrities on physical activity to follow, and develop new connections with like-minded friends in relation to physical activity. Some studies provided similar insights. A systematic review of 19 studies (targeted population were adults and adolescents) exploring mobile phone technologies (social media apps) for physical activity indicated that users' preferences for social comparison and support on physical activity promotion were mixed, some found social support and competition motivating, while others may be worried about competition on social media or applications (Tong and Laranjo, 2018). A a four-arm randomized controlled trial (RCT) study of 790 university students (mean age was 25.2 years) compared 3 social network-based exercise interventions: social comparison, social support, and a combination of social support

and social comparison, with a control group. The study found that social comparison online networks provided the most effective source of social incentives for increasing physical activity in university students when compared to participants who attended fitness classes on social media individually (the control group). Following social comparison, the social support intervention was found to be the second most effective in promoting physical activity engagement for young people in this RCT study (Zhang et al., 2016a). Overall, there are few studies that report on both competition and community support as influential factors that work together to support physical activity engagement via social media, and this is a novel finding of this study.

Within the theme of interactions, physical activity endorsement from celebrities (e.g., advertising endorsement, social media posts shared by celebrities) was an essential element to encourage physical activity engagement. In this study, adolescents explained that the perceived distance between them and the celebrities they followed were shortened due to the ability to connect (e.g., like, comment, share) through social media. A similar finding was reported by Pilgrim and Bohnet-Joschko (2019), who found that adolescents developed a sense of connection with social media influencers by viewing content presented on an influencer's social media account. This is consistent with the finding that adolescents were impressed and were incentivised to engage with physical activity from observing the physical activity that the celebrities that they followed on social media. engaged with. Overall, the Chinese adolescents were more likely to learn and imitate the physical activity behaviours that were practiced, recommended or endorsed by the celebrities they followed. In turn, it could be argued that an invisible relationship of dependency was created between influencers and adolescents related to physical activity. Adolescents' engagement with

celebrities through social media and the influence on physical activity behaviours has been reported in previous research. For example, Goodyear et al. (2019a) reported on how adolescents' perceived that celebrities provided reputable (or credible) content, that influenced how they engaged with physical activity.

Another aspect of the theme of interactions was related to showcasing achievement on social media, such as through physical activity 'punch cards' (update and show their physical activity engagement every day). It became apparent in the data set that a 'punch card' was often shared through WeChat moments and this was an important opportunity for adolescents to build their image by recording their achievements. Adolescents curation of an image through social media is consistent with previous literature (see e.g. (Wu, 2019)), although in this study new insights are provided into how physical activity engagement is used to curate an image by adolescents through social media.

The accessibility theme emphasized the learning affordances of social media use in relation to physical activity. It was claimed by adolescents in this study that social media was an optimal medium for learning. Similarly, a recent survey of 26349 students (age 6-18 years) in China reported that 88.9% of junior high school students use social media to learn (CNNIC, 2022b). In connection with this, the use of social media during the pandemic has also expanded the opportunities for adolescents to learn (Iqbal et al., 2021). Social media can support adolescent learning by providing a space to access diverse content and support interactions related to physical activity (Dabbagh and Kitsantas, 2012; Liu, 2010; Treem and Leonardi, 2013). Moreover, and

based on the study of Greenhow and Lewin (2016), social media can be an important tool for self-study, namely that the learners can control and set up their learning process, content, and methods, and, in turn, social media provides adolescents with relevant knowledge and a platform for knowledge exchange. These findings have been replicated elsewhere, with other studies showing that social media provides positive learning experiences and social support, encourages self-learning, and allows group learning (Raut and Patil, 2016).

In relation to social media, physical activity learning was mentioned by adolescents as an important channel to access physical activity related knowledge and resources in this study. A qualitative study of 49 British girls aged 13-15 years, showed that adolescent girls responded to health and sports-related posts, likes, comments and stories, and that health was an important part of their social media learning experiences (Goodyear et al., 2022). In addition to these learning mechanisms, in this study the repeat viewing of some physical activity content that may be shared by different users on social media expanded the physical activity learning. In connection with this, saving more money on physical activity learning and practice was an extra advantage mentioned by adolescents. In this study, adolescents discussed acquiring physical activity knowledge from physical activity classes or physical activity extracurricular activities, but that these did not give them the opportunity to revise related physical activity content by themselves after class. They emphasized the advantages of physical activity sources provided by social media, which enabled them to watch and review physical activity learning content at any time. In terms of health-related learning, Goodyear and Quennerstedt (2020) study focussing on British male adolescents learning about health-related topics on social media, pointed out the

potentially positive role of social media as a resource for health-related learning. As with the findings in my study, adolescents could use social media to learn more physical activity-related knowledge and they could access niche or novelty physical activity programs. This also supports social media as a valuable learning tool for physical activity. Overall, the findings from this study are coherent with other studies reporting on how social media used by adolescents supports health-related learning, and in turn, can support physical activity engagement (Goodyear et al., 2022; Goodyear and Quennerstedt, 2020).

The supervision theme highlighted that schools and parents helped supervise the physical activity engagement of adolescents through social media, in addition to traditional forms of supervision in face-to-face (or offline) contexts, e.g., physical education (PE) class, clubs and physical activity tasks after school. According to the 'Physical Education and Health Curriculum Standards for Compulsory Education, 2022 Edition'(MOE GOV, 2022), students are currently being asked to 'clock in' on WeChat groups for exercise, and physical activity 'punch cards' have gradually started to be an important part of student homework in China. In this study, while social media was used for supervision, adolescents re-enforced the role and effectiveness of supervision in face-to-face formats. The advantages of physical activity in the school environment included the experience of a livelier atmosphere that encouraged more active participation.

In this study, adolescents mentioned that parents could provide support in their physical activity, including physical activity supervision, support, and guidance. There

is evidence that parental support can encourage more physical activity in adolescents (Mitchell et al., 2012; Xu et al., 2015). One systematic review summarized that parents actively serve as sports role models through their positive attitudes towards physical activity, and provide positive encouragement and support which brings an important and deep impact on adolescents' physical levels (Edwardson and Gorely, 2010). Also, much evidence suggests that schools have a high possibility of being an effective intervention for youth physical activity by increasing the number of physical education classes and time spent in physical activity (Heath et al., 2012), especially improving the quality of physical activity experiences (García-Hermoso et al., 2020). These points align with the adolescents' reactions and claims about physical activity engagement in this study, whereby schools and parents had the advantage of adding a more meaningful physical activity experience, compared to physical activity engagement through social media. In terms of physical activity supervision, this may be the unique finding of this study, and this may relate to the cultural context. China is a country that promotes collectivism, and the emphasis on collectivism is carried out in school education. Participating in group sports gives children more encouragement and confidence. Also, adolescents in China may rely more on or follow the advice of their teachers and parents. Notably, different cultural backgrounds have an influence on adolescents motivations for adolescents for physical activity (Yan and McCullagh, 2004).

5.4.2.1　Variations in social media use and physical activity related to gender and age

In this study, variations between boys and girls related to: 1) physical activity motivation, 2) choice of physical activity-related content and 3) competition and

support on social media. The data showed that girls focused more on obvious outcomes after exercise (e.g., more preferable to watch physical activity videos that help to achieve good figure outcomes within a guaranteed period of time), but boys were inclined to choose reliable physical activity content to practise (e.g., follow more professional physical activity accounts). This finding is supported by a cross-sectional research study of Czech and Polish adolescents that showed higher appearance motives in relation to physical activity in girls, but a higher enjoyment, competence and fitness-related motivation for physical activity in boys (Frömel et al., 2022). In terms of motivation in relation to physical activity, this study showed that girls were encouraged by entertainment celebrities, but boys tended to be motivated by sports celebrities. A qualitative study explored 15-17 year-old female adolescents' perspectives about body, health, and fitness disseminated through Instagram. The participants claimed that participating in fitness on Instagram is a very convincing way to understand the body, especially if it is posted by Internet influencers or entertainment celebrities (Camacho-Miñano et al., 2019). Goodyear and Quennerstedt (2020) qualitative study focussing on British boys aged 13-15 years showed that the way that boys get motivated by social media is by accessing information about fitness and gym workouts that help them become "fit" and thus look like the fitness experts they are inspired by on social media. Moreover, in this study, girls preferred to see the performance of peers on social media, and boys preferred to be engaged in competition on social media, and these differences are evident in previous studies. For example, many studies have indicated that girls prefer challenging but non-competitive sports, more autonomy and the company or presence of friends in the context of physical activity (Azzarito and Hill, 2013; Yungblut et al., 2012). In contrast, competing with each other

has a greater impact on boys' engagement with physical activity and is an important motivation for boys to participate in physical activity (Soares et al., 2013).

With regards to the variations in age groups in this study, the variations between younger and older adolescents group related to 1) preferences of physical activity content on social media and 2) attitudes to using social media in relation to physical activity. Younger adolescents (age 12-13 years) focused more on the physical activity part of The Academic Test for Junior High School Students (e.g., watch and learn more about programs related to physical activity exam on social media), and physical activity content presented in rich formats, such as attractive headlines about physical activity, various graphic images and animations of physical activity, videos with detailed physical activity action and so on. For older adolescents (age 14-15 years), the practicality of content was their primary emphasis of engagement, and they liked the visible and obvious effects after physical activity practice (e.g., pay attention to the content related to physical activity skills on social media). There is no direct evidence to support this, but previous literature has shown that there are age differences in social media use, with older adolescents (age 14-17 years) being more concerned with self-expression, using social media more frequently, and having more of a presence on social media compared to younger adolescents (age 12-13 years) (Anderson and Jiang, 2018a; Swirsky et al., 2021).

Children and younger adolescents can be described as developing social media skills, with ownership of social media accessed devices, for instance, mobile phones slowly beginning to transition from parents to this group, and as they get older they are

becoming more socially independent and expanding their use of the social media sphere, using a wider and more diverse range of apps and social media sites (Ofcom.UK, 2023). This may reflect the fact that older adolescents are more confident, experienced and active in their social media use. This may also explain why older adolescents are more content-oriented and see the positive aspects of physical activity-related content in their social media use in my qualitative study. Younger adolescents, who may still be in the exploratory stage of social media, are more likely to consider their routine tasks, for example, sports exams. On the other hand, younger adolescents worry more about their attention on physical activity and may be distracted by other interesting content on social media. There is evidence showing that self-control increases with age in adolescents (Shulman et al., 2015; Zondervan-Zwijnenburg et al., 2020). They develop greater self-control and are comfortable in dealing with different social media content and environments as they age.

5.4.3 Study strengths and limitations

A key strength of this study is that the conceptual focus was on adolescents' interaction with physical activity-related content on social media. Furthermore, new insights were provided into gender and age-based differences, based on the qualitative data. This is an original part of this study, which clearly shows the different uses of social media in relation to physical activity and in the context of different demographics of participants. I, as the first researcher, led the analysis and this was a key strength to data collection and analysis because my cultural background offered a relevant lens to interpret Chinese adolescents' engagement with social media (e.g. punch cards,

supervision, idol chasing). The self-reflexive process here involved the diverse analysis team, providing multiple lenses through which to interpret the data and to ensure wider interpretations of the data were possible, and that these findings could be applicable to other research contexts. My study has provided a first-hand insight into Chinese adolescents' experiences in social media and physical activity. In the future, this could be explored further to understand differences across regions, given the vast geographical location of the country. As a one-off focus group study, some drawbacks are inevitable. Considering adolescents' uses of social media are dynamic, a one-off interview perhaps isn't sufficient to understand the complexity of social media behaviours and how they relate to physical activity comprehensively and thoroughly. Due to the nature of focus groups, it may also cause some personal ideas not to be shared in the groups.

5.4.4 Implications and future research

These findings have implications for understanding how social media can be used to support physical activity engagement, and from the perspectives of Chinese adolescents. Notably, the Chinese population provides a new lens through which to understand physical activity engagement and social media use, due to differences in culture, context, and income. Based on the traits and affordances of social media, this study provides insights into adolescents' demands and preferences for social media use in relation to physical activity. The themes in this study have summarised useful information about the content on social media that may attract adolescents to engage with physical activity and the preferences for different physical activity content.

Evidence suggests that physical activity could be promoted by social media (Goodyear et al., 2021a; Parker et al., 2021; Van Woudenberg et al., 2020). The evidence generated from this study on social media use in relation to physical activity among secondary school adolescents is a good reference for schools and parents, indicating that as well as potential issues, social media use may have some advantages in relation to its use for physical activity. These advantages include supervision, convenience, accessibility and positive interaction, and these elements could be applied to future guidance on how to use social media to support physical activity engagement. This is also an opportunity to raise awareness of the potential of social media in relation to physical activity in the government, schools, and parents. In connection with the current policy in China of one hour physical activity in secondary students (GOV.cn, 2007), social media could be a promising tool to help achieve this aim. Future research could therefore focus on social media interventions or similar applications that could increase physical activity engagement. Based on the findings from this study, physical activity interventions may consider combining social media and real-life support, such as from schools and parents, to enhance adolescents' physical activity engagement.

5.4.5   Conclusions

The present study was designed to explore social media use in relation to physical activity among Chinese adolescents. The main objectives were to explore the social media content that adolescents' access in relation to physical activity and the content that influences adolescents' physical activity attitudes, knowledge, and behaviours, and to explore the risks, and opportunities that adolescents report in relation to social

media use related to physical activity engagement. Significant findings to emerge from this study include three main themes, namely interaction, accessibility, and supervision, reflecting how adolescents understand and participate in physical activity through social media. Furthermore, this study reported on differences in social media use in relation to physical activity among boys' and girls' and younger and older age groups. This study provides a clear perspective on how Chinese adolescents use social media to access physical activity content and how that content influences their physical activity engagement. Social media has been highlighted by many studies to have the potential to improve and encourage more physical activity engagement. In the future, how to provide more targeted social media programs and content for adolescents and different groups to encourage more physical activity participation, may need to be explored further.

CHAPTER 6 SOCIAL MEDIA USE AND PHYSICAL ACTIVITY – A MIXED METHOD APPROACH

6.1 Mixed method approach

Having set out the quantitative and qualitative research in the previous two chapters, this chapter will combine the findings relating to social media use and physical activity in a process referred to as an explanatory sequential design. Creswell and Clark (2017) described and summarised three core mixed method designs, namely convergent, explanatory sequential, and exploratory sequential.

Convergent design refers to research that collects both quantitative and qualitative data at the same stage of the research process. In a convergent design, methods are given equal importance and data collected from quantitative and qualitative studies are analysed independently but are then blended during interpretation (Creswell and Clark, 2017). The explanatory sequential design collects and analyses quantitative data first and then qualitative data. In the interpretation phase, qualitative results are used to help further interpret the quantitative findings (Creswell and Clark, 2017). The exploratory design collects and analyses qualitative data, and then based on the results of the qualitative study, a quantitative study is designed and conducted (Creswell and Clark, 2017).

In this study, an explanatory design was adopted. This approach was beneficial because the results from the qualitative study helped to explain the results from the quantitative study. Indeed, explanatory designs are appropriate when qualitative

results are better used to explain differentiating quantitative results, such as quantitatively significant (or non-significant) results, unusual results, or novel results (Curry et al., 2009; Morse, 1991). The explanatory sequential approach is illustrated in Figure 13.

6.1.1   The explanatory sequential design

Although an explanatory sequential design was used in this study, the data collection and analysis of the quantitative and qualitative studies were conducted concurrently. This concurrent approach was partly for pragmatic reasons, as time was limited due to the pandemic and so the studies could not be conducted sequentially. As Creswell and Clark (2017) argued, the designs of studies change over time and during data collection, and in some cases, the "sequential" part is omitted. This tends to happen because quantitative and qualitative data are collected simultaneously, and the term more highlights the intent of the design, that is, the method by which the researchers mix the results obtained quantitative and qualitative studies.

In this study, the independence of the quantitative and qualitative studies during the design, data collection, and analysis stages was helpful as it allowed greater freedom when considering different ways in which the qualitative findings may be used to interpret the quantitative findings. It also allowed a more inductive approach to exploring qualitative questions, with the analysis driven by the participants' perspective. Over the whole study, the final presentation of results consists of a quantitative results section (chapter 3), a qualitative results section (chapter 5), and an explanatory results

section (chapter 6) so that it is clear to read and provides a clear perspective to understand (Creswell et al., 2003).

Figure 13 Illustration of the explanatory sequential design
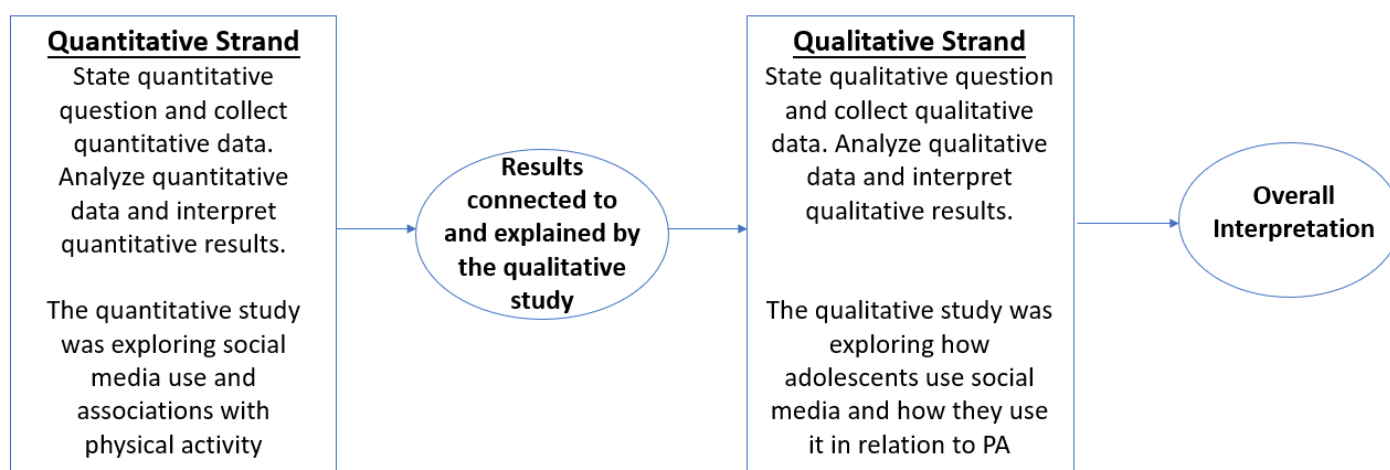
This figure is adapted from (Creswell et al., 2003)

6.1.2 Summary of the study participants and the quantitative and qualitative methodological approaches

Six secondary schools, located in Hefei China, were invited to participate in this study. 4791 adolescents who were aged 12-15 years old took part in a quantitative study (survey) and 48 students from two schools took part in focus groups (8 focus groups in total) in the qualitative study. All participants invited to the FGs were social media users and each focus group included participants with low, medium and high physical activity levels (Chapter 5).

In the quantitative study, different aspects of social media usage were measured, including time-related measures (duration, frequency, and specific use time), reasons for social media use, and accessing/posting content on social media (Chapter 3, Section A). The associations between these aspects of social media use and measures of physical activity time and weekly leisure time were explored using regression modelling (Chapter 3, Section B).

In the qualitative study, focus group discussions were used to explore the relationship between the following aspects of social media and physical activity: a) Why and how do adolescents use social media? b) What types of social media content do adolescents access and use (or not) in relation to physical activity, and why? c) What types of social media content do adolescents report as influential on their physical activity attitudes, knowledge and/or behaviours? d) What risks and opportunities do adolescents report in relation to their use of social media and physical activity? The data were analysed using thematic analysis (Braun and Clarke, 2006).

6.1.3 Integration strategy for the Quantitative and Qualitative Strands

Before conducting the integration of quantitative and qualitative study findings, there are two concepts that are useful to clarify to help understand the mixed method approach, namely the point of interface and mixing strategies.

The point of interface is a point within the process of research where the quantitative and qualitative strands are mixed (Morse, 2016). There are four possible points that

mixing occurs: design, data collection, data analysis, and interpretation. In this study, the point of integration happened at the interpretation stage, which followed design, data collection and analysis of the quantitative and qualitative studies, which were conducted in parallel.

When integrating data, the mixed methods matrix was applied. Based on O'Cathain et al. (2010) and Creswell and Clark (2017), the mixed methods matrix is a good method to integrate and present mixed-method data considering the availability of both qualitative and quantitative data on the same cases. The specific process involved comparing results in the quantitative study with results in the qualitative study in a matrix. Given the explanatory sequential design, the quantitative results were listed in the first column, and the qualitative results were listed in the second column of the matrix. All results of the quantitative study listed in this chapter could be linked and explained by qualitative study.

6.2 Results

The matrix in Table 22 shows where the qualitative study findings map to the quantitative study findings and provide a potential explanation.

Table 22 Explanatory qualitative study findings mapped to quantitative study findings

Key findings in the quantitative study*	Explanatory findings from the qualitative study	
Social media use in general		
Types of social media content that were rated as important to participants were: entertainment (26.19% of participants), contact with family (20.16% of participants) and friends (32.85% of participants)	**Theme 1. Social media functions and potential problems**	
	Participants described using social media to enrich their after-school life (Browse TikTok, play games, chat and communicate with friends, follow the dynamics of celebrities)	
46.34% of participants were likely to access entertainment content (e.g., music, sport, memes, videos, gaming – including celebrities or influencers); 21.71% of participants liked to use social media to access news information 45.71% and 24.63% of participants would post about their daily lives and about themselves respectively; 31.54% and 19.43% of participants accessed or posted content related to their friends and families respectively	**Differences in different genders and ages**	In terms of enriching after-school lives, girls focus on celebrities, boys play games, younger adolescents use social media for connections and friends, and older adolescents have more autonomy and use it as an educational tool
Social media usage in relation to PA		
21.75% of participants used social media to access health-related information	**Theme 2: Accessibility**	
12.98% of participants posted health related information on social media	Social media provides many physical activity learning opportunities (e.g., more formats of physical activity resources prevailed in social media, such as videos, pictures, and GIFs)	

Moderate social media use is associated with higher intensity of weekly leisure activities Social media usage time is negatively associated with the number of days adolescents are physically active for at least 60 minutes	Participants recognised pitfalls when using social media for physical activity learning (e.g., safety, not systematic learning, more interesting content may attract their attentions, other interesting content on social media distracted them from physical activity content on social media)
	Theme 3: Interactions
	Social media provides a platform and brings a sense of community for adolescents to create an enthusiastic atmosphere to discuss physical activity-related content and show physical activity-related achievements.

*Only the quantitative findings that the qualitative findings map to are included in this table

There was concordant evidence from both studies that social media provides ways of enriching afterschool life, with entertainment and contact with friends being highlighted in both studies. A high proportion of adolescents (46.34%) reported accessing entertainment content in the quantitative study. The qualitative study provided further information, as adolescents mentioned that social media supplements routine life and there were differences reported between genders in the after-school use theme. Girls were more inclined to engage with celebrity and influencer content than boys. In contrast, boys were more inclined to play games and watch funny videos as a form of entertainment. In the quantitative study, findings showed that 31.54% and 19.43% of adolescents accessed or posted content about friends and family. In connection with this, the qualitative findings suggested that it was the younger adolescents who used social media in more social and connected ways (e.g., making friends, liking other people's posts). In the quantitative study, 21.71% of participants liked to use social media to access news information, and 45.71% and 24.63% of adolescents would post about their daily lives and about themselves respectively. In connection with this, older adolescents were more likely to have their own autonomy and ideas when using social media (e.g., using it as an educational tool, learning more about the outside world, and expressing their feelings more freely), as evidenced in the qualitative study.

The results of the quantitative and qualitative studies showed adolescents utilised social media to access and discuss content related to physical activity. The findings from the quantitative study showed that health information was a key form of social media content that was accessed by adolescents (21.75%), and further extension of this was given in the qualitative study, where adolescents mentioned rich resources related to physical activity, physical activity knowledge, and to physical activity lessons

on social media. In the quantitative study, data from the survey showed that 12.98% of participants posted health-related information on social media. The qualitative study adds further explanation to this as it showed that adolescents liked to post their own physical activity-related achievements of themselves and used social media as a platform to discuss physical activity-related content and create an environment to encourage physical activity amongst their peer group.

In the quantitative study, adolescents used social media to access physical activity information. Compared to adolescents who did not use social media, moderate use of social media (i.e. less than 2 hours) was associated with a higher proportion of time spent in leisure time activity. However, a negative association was found between the time spent on social media and time spent in physical activity, indicating that the proportion of time spent on social media may negatively influence physical activity engagement. The qualitative study provided evidence that partially complement both of these findings. Social media supported adolescents to learn new physical activity skills, but there were concerns reported about the appropriateness of the content related to physical activity (e.g., safety, no systematic learning, etc.). Overall, adolescents perceived that social media can pose both risks (e.g., more interesting content may distract them) and benefits (e.g., learning resources, physical activity knowledge) to physical activity engagement.

6.3 Discussion
6.3.1 General social media usage

Regarding general social media usage, both the quantitative and qualitative studies showed that social media plays and important part in after school leisure time, particularly content relating to entertainment, but the qualitative data showed differences between boys and girls. This is supported by research conducted in the last 5 years in both the US and the UK.

The Pew Research Centre and Ofcom have reported on the different preferences for social media apps by adolescents., For example, girls are more likely than boys to use Snapchat and Instagram, while boys are more likely than girls to use YouTube and Reddit (Anderson and Jiang, 2018b; Ofcom.UK, 2023; Vogels et al., 2022). This study revealed differences in what social media was used for by gender, with girls' dominant uses related to interactions and boys' related to gaming.

Both quantitative and qualitative studies have shown that teenagers visit or publish posts related to friends and family and use social media in a social way. Common examples include making friends and liking other people's posts. Similarly, the previous research by the Pew Research Centre and Ofcom provided evidence which aligns with this (Anderson et al., 2022; Ofcom.UK, 2023). The results of both demonstrated that adolescents use social media to communicate information with friends and that social media can also be used to maintain contact with parents. In this study the quantitative data showed that adolescents are using social media to explore news and information, and the qualitative data illustrated that it tends to be older adolescents use it more for exploration and expressing their views. The Pew Research Centre's research and some other studies also reported that social media supported

this age group through difficult times, and provided a platform where they feel free to express themselves creatively (Anderson et al., 2022; Wilson et al., 2012; Yang et al., 2018).

6.3.2   Social media use in relation to physical activity

Both the quantitative and qualitative studies showed that health information was a key form of social media content that was accessed by adolescents. Further explanation of this was given in the qualitative study, where adolescents mentioned detailed social media physical activity content such as resources, knowledge, and workout videos. This use of social media for learning and expanding knowledge has been highlighted in previous studies (Greenhow and Lewin, 2016; Mao, 2014; Moghavvemi et al., 2018). The positive aspects of social media in relation to learning include, but are not limited to, opportunities for collaborative learning, potential interaction with others, multifaceted exposure to knowledge, increased participation in the curriculum and increased motivation for learning (Bilandzic and Foth, 2013; De-Marcos et al., 2016; Hu et al., 2017; Pimmer et al., 2016). There is also previous evidence to show that the type of health information that adolescents access relates to aspects of lifestyle, such as eating healthily or doing exercise (Lin and Zhu, 2012; Chassiakos et al., 2016; Villiard and Moreno, 2012; Wong et al., 2014).

The quantitative study identified that adolescents posted content related to health. The qualitative study further explained the types of content and showed that adolescents communicated and interacted with others about physical activity-related topics, sharing their thoughts on physical activity (by leaving comments under posts, and/or

forwarding relevant pictures and videos). This finding also develops the data from emerging studies that show how adolescents interact with health-related content through the varying functions of social media: likes, comments, stories, videos (Goodyear et al., 2021b; Hausmann et al., 2017; Leary et al., 2019; Plaisime et al., 2020). This finding indicates that these features of social media could be used in the context of physical activity promotion with adolescents.

There were two seemingly conflicting findings in relation to social media use and physical activity in the quantitative study, with overall physical activity levels negatively associated with time using social media, but leisure time activity positively associated with moderate social media use, and there are aspects of the qualitative data that help provide explanations for both of these findings. The qualitative findings both suggest that social media can help adolescents to do exercise and physical activity but may also hinder them. Social media's ability to distract adolescents should not be underestimated. Adolescents articulated in the qualitative study that other interesting content on social media (e.g., entertainment related information) distracted them from physical activity content on social media. Also, time spent on social media may displace the time spent on physical activity. A cross-sectional study of 116,615 Chinese schoolchildren aged 9 to 17 years who participated in the 2016 China Physical Activity and Fitness-Adolescent Study showed that Chinese adolescents face the challenge of how they manage their screen time, which undoubtedly greatly reduces the leisure time of adolescents for physical activity (Cai et al., 2017). From this mixed method study, measuring time on social media does not provide sufficient depth of understanding of how social media influences physical activity. The data from the qualitative study suggests that we should be focusing on content and the types of

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physical activities adolescents engage with. The value of the mixed-method study is clear here, because the qualitative study brings a unique angle to supplement and explain the quantitative study, which enables a more nuanced picture of the relationship between adolescents' social media use and physical activity behaviours.

Taking this analysis further, and given the potential benefits of engaging with physical activity content, it is worth thinking about what type of physical activity content would positively influence adolescents physical activity engagement. It was evident from the qualitative data that high-quality information related to both health and physical activity was crucial. Notably, participants expressed concerns around the quality of physical activity content that they saw on social media. Previous evidence has also highlighted that the varying quality of health information can be an issue, with adolescents and people expressing concern about the low quality or misleading health information shared on social media, and social media users may not have the means to judge the reliability of the information, especially when the platforms are pushing popular health-related content (Freeman et al., 2023; Moorhead et al., 2013; Ventola, 2014).

6.3.3   Strengths and Limitations

Mixed methods research on adolescents uses of social media and physical activity is very limited. The quantitative and qualitative data integration that I present here adds understanding on how adolescents use physical activity-related social media content and how social media influences their physical activity. This study, therefore, provides information for future research directions on social media and physical activity and potential social media based physical activity interventions. In terms of the mixed

method approach that I used, the explanatory sequential design makes intuitive sense. It can be seen from the findings presented in this chapter that the quantitative and qualitative studies provided different perspectives that complemented each other, with the qualitative study focused on how social media content (generally and in relation to physical activity) is accessed and used, which provided explanations for some of the observations made in the quantitative study. Thus, I have been able to provide not only an overview of how adolescents use social media and how this may influence physical activity among adolescents, but also provide the details about how adolescents engage with social media physical activity content and the corresponding potential issues they may face during social media use.

There are some limitations of this mixed-method study. Adolescents also mentioned the offline physical activity opportunity in the qualitative study, but this was not covered specifically in the quantitative research questions, so there is no opportunity to further our understanding of how physical activity can be holistically supported. The off-line physical activity mentioned by adolescents included not only the help of social media in terms of monitoring, but also the efforts of wider stakeholders (like schools, teachers, and parents). I conducted quantitative and qualitative studies almost simultaneously, so there was no opportunity to refine my qualitative data collection approach in response to my quantitative findings. The consequence of this is that parts of the quantitative study findings can be explained by the qualitative study, but other findings were not specifically explored. The qualitative study findings regarding social media usage in relation to physical activity across gender and age groups cannot explain the results of quantitative study, but the study has enhanced understandings of social media use in full by adolescents.

6.3.4 Conclusion

Integration of the quantitative and qualitative findings of the thesis has created additional understanding in relation to Chinese adolescents' use of social media. The mixed methods study has highlighted some of the reasons that may underlie the observed patterns of social media use and associations between social media and measures of physical activity. As well as further developing our understanding of how Chinese adolescents use social media in general, the findings enable a more comprehensive picture of the relationships between adolescents' social media use and physical activity engagement. In particular, the qualitative data starts to help us explain the somewhat counterintuitive findings of the associations between social media use and overall physical activity and leisure time physical activity observed in the quantitative study. In addition, focusing on time spent on social media and its association with two specific measures of physical activity (as in the quantitative study) does not provide a sufficient depth of understanding of how social media affects physical activity. The results from the qualitative study, therefore, are valuable in that they help to explain adolescents' physical activity and social media relationships from multiple dimensions, including the content and types of physical activities youth participate in and how this is supported (or hindered) by social media.

CHAPTER 7 SUMMARY
7.1 Health issues facing adolescents and relationship with social media use

Current societal conditions have resulted in several health challenges for adolescents, some of which are highlighted in this research. According to the World Health Organization (WHO, 2021), around 14% of adolescents aged 10 to 19 years worldwide suffer from some degree of mental health problem. In recent decades, the decreasing amount of sleep and poor sleep quality during adolescence is a concern, especially in Asian countries (Gariepy et al., 2020; Gradisar et al., 2011; Sturman and Moghaddam, 2011; Wang et al., 2019; Zhang et al., 2016b). Physical inactivity among adolescents is also a concern. A survey of 16 million adolescents (age 11-17 years) from 146 countries showed that 81% of adolescents (85% of girls and 78% of boys) do not meet the current recommendation of at least one hour of physical activity per day (Guthold et al., 2020).

Related to these, social media has become an integral part of adolescents' lives and a very popular form of communication among adolescents (Anderson et al., 2022; Vanden Abeele, 2016). Previous studies have explored some of the problems of social media and the effects on adolescent health, particularly in relation to mental health and physical activity. However, our understanding of how access to and use of electronic and social media affects the health of children and adolescents is not robust. One reason for this is that technology is constantly evolving and is expanding its scope of application. An obvious example is that with the popularity of DouYin (TikTok), short videos are quickly winning over users and changing the mode of social media use for

many users. Another reason is that adolescents are spending an increasing amount of time on electronic devices and social media, and using them in an expanding range of scenarios. According to a survey of U.S. adolescents published by Common Sense Media, their social media usage increased by 24% from 2019 to 2021 alone (1h27min vs 1h10min), which is a faster increase than in the previous four years (Rideout et al., 2021). There are some challenges and gaps within research in this area, such as limited ability to measure screen and social media use by adolescents accurately; a reliance on cross-sectional studies; limited evidence from Asian contexts or the Global South; little evidence on how use varies with gender and age (and interaction with screens and social media develops over time throughout adolescence); and little understanding of use in vulnerable adolescents. Although previous studies have established correlations between social media use and adolescent health (Alonzo et al., 2021; Best et al., 2014; Fonseca et al., 2021; Goodyear et al., 2021a; Keles et al., 2020; Laranjo et al., 2015), the timeliness of the research is very important, and the development of social media technology and adolescents' development during their growth process needs to be integrated and explored contemporaneously.

7.2 The main work of this thesis

This thesis used a mixed-method approach to explore the impacts of screens and social media use on mental health outcomes, sleep, and physical activity among adolescents aged 12-15 years in China. Data were collected from surveys and focus groups during 2020-2021, involving 4791 adolescents from six secondary schools in Hefei, in the Anhui province of China. The previous chapters report on the findings from the quantitative, qualitative and mixed methods analyses.

7.3 Findings of this study in context

Most previous research into adolescents, screens, social media and mental health has focused on screen time. Overall, the evidence suggests a u-shaped relationship, in that moderate usage of screens and social media can be beneficial for mental health outcomes, whereas higher levels of use have the opposite effect. However, the threshold at which beneficial effects are reversed is not completely clear. Previous studies have suggested that harm is apparent from 2 or more hours of screen time and this has informed the American Academy of Pediatrics (Strasburger et al., 2013) recommendations for screen time use in adolescents. There are also a few studies which have shown that 2 or more hours of social media use may be associated with detrimental effects on mental health (Liu 2016; Sampasa-Kanyinga and Lewis, 2015; Twenge et al., 2018; Twenge and Campbell, 2019). The existing research, however, is predominantly based on populations in western cultures and may not be as relevant to Chinese adolescents, given the unique online and social media context in China. China's extensive censorship of social media sites around the world and the creation of many alternative China-specific platforms for Chinese users make the Chinese social media ecosystem different from that of other countries and regions. Yet the quantitative findings from this thesis confirm and strengthen previous findings that there are beneficial mental wellbeing effects for adolescents who have social media use up to 2 hours per day, as well as a positive association with leisure time physical activity. My findings also suggest that once social media use exceeds two hours, negative health effects are apparent, including poorer quality and shorter duration of sleep, higher levels of anxiety, and lower physical activity levels. As such, this study provides new and robust evidence on the generalisability of previous research and

can be used to inform international policy debates on social media guidance for adolescents.

Some previous studies have explored how social media may be used to influence adolescents to engage in physical activity (Van Kessel et al., 2016a) and how adolescents interact with health-related social media content (Goodyear et al., 2019c). However in this thesis, I expanded on these themes by exploring more specifically how adolescents interact with, access and use social media in relation to physical activity. I found that adolescents communicate about physical activity on social media through a range of networks and use different opportunities and resources to learn about physical activity. Social media was also identified as a tool for supervision of adolescents' physical activity by parents and teachers.

My mixed-methods synthesis allowed me to interpret how the amount of time spent on social media and the content that is accessed interact to influence adolescent physical activity behaviours. I found that social media provides ways of enriching afterschool life, with entertainment and connection with friends being important elements. The findings from both the quantitative and qualitative studies illustrated that adolescents use social media to access and discuss content related to physical activity. Whilst such interaction has the potential for positively influencing physical activity engagement among adolescents, my findings also identified potential harms. From the quantitative study, the u-shaped relationship between social media use and physical activity levels suggests an optimum usage time of 2 hours per day. The qualitative study findings suggest that whilst social media use can support learning of new physical activity skills,

concerns around safety, or lack of a systematic process may limit the benefits. This is likely to be an ongoing and evolving issue as technological changes, with AI tools, and their interaction with social media use, bringing a new dimension to how adolescents engage with social media.

7.3.1 Social media use, physical activity and gender

According to a longitudinal analysis of 17409 British young people (age 10-21 years) by Orben (2020), social media use influences mental health and life satisfaction in boys and girls at different times in their development. However, little is known about social media use and gender in the context of physical activity. In this thesis I explored how gender relates to social media use and physical activity in adolescence. During adolescence, the impact of social media use on physical activity levels differs between boys and girls. Whilst longer social media usage time was associated with less physical activity time in both genders, this was more marked in girls. Also, more social media usage time was associated with higher intensity of weekly leisure time activity in boys, but this association was less in girls. Also, the content and purpose of using social media in relation to physical activity differed, with a greater focus on appearance and celebrity engagement among girls and on competition and accuracy in boys.

7.3.2 Social media use, physical activity and age

Although previous research suggests that social media may be a mechanism for supporting physical activity in young people (Goodyear et al., 2021a; Rose et al., 2017; Van Kessel et al., 2016a), it is not known how social media use in relation to physical activity may vary with age. In this study, the negative impact of higher social media

usage time on physical activity levels was mainly seen in younger adolescents. The positive association between time using social media and the intensity of weekly leisure time activity was larger in the older adolescent group than in the younger group. Moreover, the type of physical activity content accessed on social media varied across age groups, with more physical activity content related to physical activity exams and posted by Internet celebrities accessed by adolescents aged 12-13 years. However, this age group were more worried about being distracted from the physical activity content by other interesting content. The 14-15 year age group accessed more content related to gaining exercise skills and which emphasised the visible and obvious effects after practice. They were less likely to be worried about being distracted by other content. In summary, older adolescents were more confident and familiar with utilizing physical activity content on social media to help them, while younger adolescents were in the process of exploring and adapting to social media content about physical activity. This is in keeping with the wider social and psychological development and increasing independence that occurs during adolescence (Christie and Viner, 2013).

7.4 Implications for public health

According to a narrative review by Kanchan and Gaidhane (2023), social media has a substantial role in public health engagement and promotion. User engagement and retention rates on online social networks are usually high (Davies et al., 2012) and because social media allows users to take an active role and create content, it is more influential than traditional websites (Thackeray et al., 2008) and forms a unique user ecology. Various studies have outlined the potential of social media as a health intervention tool, particularly in engaging with supportive friends and family, health behaviour change, health counselling, medical education, disease outbreak

surveillance, health research, and more (Abroms, 2019). Therefore, there is a need to understand the role of the use of social media for public health intervention in the adolescent population.

Based on my findings, moderate social media usage may lead to better mental health, but excessive social media time may lead to negative health outcomes. In line with this finding, the Cyberspace Administration of China piloted a "Youth Mode" for online games, short video platforms, and live streaming platforms in March 2019, which regulates minors' online behaviour in terms of length of time and browsing content (News.cn, 2020). After entering the "Youth Mode", the cumulative duration of social applications use cannot exceed 40 minutes. After 40 minutes, if adolescents want to continue using it, they need to enter a password. In addition, there are adjustments to the content. In the "Youth Mode", adolescents have more possibilities to access social media content related to education and knowledge, and other content suitable for adolescents (News.cn, 2020). To strengthen the protection of minors, the Chinese government is planning to upgrade the "Youth Mode" to a "Minor Mode" to further manage smartphone and social media use in children and adolescents.(Cyberspace Administration of China, 2023). Under this mode, users under the age of 8 years must not use smartphones for more than 40 minutes a day, users between the ages of 8 and 16 years must not use them for more than one hour a day, and users between the ages of 16 and 18 years must not use them for more than two hours a day. In addition, minors will be denied access to social media apps from 22:00 to 06:00 each day. On the other hand, in this study the relationship between social media usage time and physical activity levels varied across adolescents of different genders and ages. Specifically, the negative association between social media usage time and physical

activity time was more notable in girls and younger adolescents, which suggests that social media management should be based on different adolescent segments.

In terms of social media content in relation to physical activity, adolescents may have different preferences. Communications and competitions on social media may encourage adolescents to engage in physical activity more. Other suggestions for using social media to encourage physical activity, based on the findings of my study, could include attractive physical activity content and social media campaigns of physical activity. However, use of social media to encourage physical activity would need to be coupled with ensuring a healthy and safe level of social media usage time. Another point that deserves attention is that adolescents of different genders and ages have different preferences and attitudes towards various content in relation to physical activity, therefore strategies need to be identified to encourage and allow different groups to access high-quality content that caters to their requirements. For example, designing more content to appeal to girls about the image benefits of exercise or more content aimed at 14-15 year olds related to exercise skills.

Ensuring a positive and healthy social media environment and encouraging healthy use of social media by adolescents will require multisectoral action, involving parents, schools, and governments. The previous evidence shows that reasonable and healthy social media use during adolescence requires supervision and mediation by parents and schools (Dennen et al., 2019; Douglas et al., 2023; Martins et al., 2020). Schools and parents are also important participants in advocating and promoting adolescents' physical activity (Cale, 2023; Edwardson and Gorely, 2010; Rhodes et al., 2020).

7.5 Future research directions

Adolescents and younger children are growing up in the social media era, and there is no denying that they will be impacted vastly by social media, but adolescents are also well poised to adapt and learn how to exist in the digital era. Although some voices say that social media is detrimental for adolescents, deeper and wider explorations of social media use in adolescents (using an array of measures of social media) and how this relates to physical and mental health, would give a more rounded and nuanced view of the impact of social media use on adolescents' lives and health, including use of social media for health intervention.

In future research, we need to further understand the interaction between social media content and duration of use and the positive and negative effects of this interaction. It is also important to identify which groups of adolescents may benefit from aspects of social media in specific contexts and how to make beneficial content more accessible. Research should focus on how social media can be used to positively engage adolescents and improve their health, incorporating multiple stakeholders (such as peers, parents, and schools) to create a healthier social media usage environment and improve health-related behaviours. Meanwhile, social media use in vulnerable adolescent groups (such as adolescents with psychological distress, disabled, or school leavers) also needs more attention from researchers. In the future, more longitudinal studies (to give stronger evidence for causal relationships between social media and health outcomes) and qualitative studies are also needed to continue exploring more health-related aspects related to adolescents' use of social media. These types of studies, together with mixed-methods approaches to synthesis

quantitative and qualitative findings, will lead to the development of a strong evidence base to guide adolescent social media use so that it leads to a more beneficial impact on health.

Social media use among adolescents continues to grow at an even faster rate, and as the landscape is rapidly changing, the research significance of social media on adolescent health is also gradually reinforced. Another point to consider is that there is a lot of potential for AI technology to be tapped into for the management and governance of social media with the technology consistently evolving. Applying AI to detect social media usage data, predict potential usage models, and generate reasonable problem-solving schemes can help stakeholders create timely insights into social media and how it benefits adolescent health.

APPENDICES
8.1 Appendix 1

Appendix 1 Explanation of the range of values of pre-existing scales used in the school student survey

Scale name	Score range of scale	Meaning of scores
Social Media Motives Questionnaire	1-5 scores in 16 items (in total 4 motives) Total scores (4-20) in each motive	Higher scores indicate higher levels on each motive
Problematic Social Media Use	1-8 score in 15 items (The items were rated on an 8-point scale Total scores (15-120)	Higher scores indicate higher level of PSMU
Rosenberg Self-esteem Scale (RSES)	0-3 scores in 10 items, containing forward and reverse scoring. Total score (0-30)	Higher scores indicate higher self-esteem
Social Comparison Rating Scale (SCR)	10 scores in 11 items A self-report measure that presents respondents with 11 items of bipolar constructs. Total score (11-110)	Higher scores mean more positively compare oneself with others while using social media
Short Warwick-Edinburgh Mental Wellbeing Scale (SWEMWBS)	1-5 scores in 7 items Total scores (7-35)	Higher scores mean better wellbeing
Generalized Anxiety Disorder 7 items (GAD-7)	0-3 scores in 7 items Total scores (0-21)	0-4: minimal anxiety 5–9: mild anxiety 10–14: moderate anxiety 15–21: severe anxiety
Kutcher Adolescent Depression Scale (KADS)	0-3 scores in 6 items Total scores (0-18)	0-5 no depressive symptoms >= 6 depressive symptoms
Sleep quality (subscale of the Adolescent Sleep Hygiene Scale (ASHS)	6-1 scores in 11 items Average scores (1-6)	Higher scores mean higher quality of sleep
Daytime sleepiness (subscale of the ASHS)	6-1 scores in 2 items Average scores (1-6)	Lower scores mean more sleepiness in the daytime

Youth Risk Behaviour Survey (YRBS)	"During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day? (A. 0 days B. 1 day C. 2 days D. 3 days E. 4 days F. 5 days G. 6 days H. 7 days)"	Recommendation of 60 minutes or more of moderate-to-vigorous physical activity daily in adolescents
Godin Leisure-Time Exercise Questionnaire	"During a typical 7-Day period, how many times on the average do you do the following kinds of exercise for more than 15 minutes during your free time (write on each line the appropriate number)" Weekly leisure activity score = (9 × Strenuous) + (5 × Moderate) + (3 × Light)	24 scores or more mean active PA 14 – 23 scores mean moderately active PA Less than 14 scores mean sedentary PA

Note: PA = physical activity

8.2 Appendix 2

Appendix 2 A copy of questionnaire----Screen time, electronic devices and social media use among adolescents in China and associations with mental health, sleep, and physical activity

Basic information	
Which school do you attend?	
Which grade and class are you in?	
What's your name?	
Date of filling in this survey	
You and your family	
What is your date of birth?	
How old are you?	□ Less than 12 years old ------- 0 □ 12 years old ------ 1 □ 13 years old ------ 2 □ 14 years old ------ 3 □ 15 years old ------- 4 □ Older than 15 years old ------- 5
What is your gender?	□ Male ----- 0 □ Female ----- 1 □ Prefer not to say ----- 2 □ Other ----- 3
Which school do you attend?	
Which grade are you in?	
Which class are you in?	
What is your father's highest level of education?	□ Lower than undergraduate (senior high school or lower) ---- 0 □ Undergraduate (bachelor, or equal degress in university & collage) ---- 1 □ Postgraduate and over (Master or PhD) ---- 2
What is your mother's highest level of education?	□ Lower than undergraduate (senior high school or lower) ---- 0 □ Undergraduate (bachelor, or equal degress in university & collage) ---- 1 □ Postgraduate and over (Master or PhD) ---- 2
Screen time, electronic devices and social media	
How long do you spend overall using screen-based devices (such as TV, mobile phone, laptop, computer game console, tablet or other electronic devices) on an average school-day? (Please exclude computer class time at school)	_____ Hours
How long do you spend overall using screen-based devices (such as TV, mobile phone, laptop, computer game console, tablet or other electronic devices) on an average weekend day?	_____ Hours
Which of the following screen-based devices do you use and how much time do you spend on these on an average school day? (Please exclude computer class time at school) **TV Mobile phone Laptop Computer Game console Ipad Other**	_____ Hours
Which of the following screen-based devices do you use and how much time do you spend on these on an average weekend day? **TV Mobile phone Laptop Computer Game console Ipad Other**	_____ Hours

Which of the following social media platforms do you use the most? (Please up to tick 3 platforms)	☐ QQ social_media_type___1 0=no / 1=yes ☐ WeChat social_media_type___2 0=no / 1=yes ☐ Duitang social_media_type___3 0=no / 1=yes ☐ Huaban social_media_type___4 0=no / 1=yes ☐ Jinritoutiao social_media_type___5 0=no / 1=yes ☐ Yidianzixun social_media_type___6 0=no / 1=yes ☐ Youku social_media_type___7 0=no / 1=yes ☐ Tecent Vedio social_media_type___8 0=no / 1=yes ☐ Bilibili social_media_type___9 0=no / 1=yes ☐ TikTok social_media_type___10 0=no / 1=yes ☐ Sina Weibo social_media_type___11 0=no / 1=yes ☐ Baidu Tieba social_media_type___12 0=no / 1=yes ☐ Renren social_media_type___13 0=no / 1=yes ☐ Zhihu social_media_type___14 0=no / 1=yes ☐ None, I don't use social media social_media_type___15 0=no / 1=yes ☐ Other (please specify) _____ social_media_type___16 0=no / 1=yes
(Motivation of Social Media Use) Thinking about your social media use in the last 12 months, please answer the following questions on a scale of 1 to 5 (1= never or almost never; 5 = always or almost always) Please Use "✓" or circle to indicate your choice. How often do you use social media: **Total scores (4-20) in each aspects** **4 aspects: Coping / Conformity / Enhancement / Social** **Higher scores indicate higher levels on each motive**	1) To forget your worries? 1 2 3 4 5 2) Because it helps you when you feel depressed or irritated? 1 2 3 4 5 3) To cheer yourself up when you are in a bad mood? 1 2 3 4 5 4) To forget about your problems? 1 2 3 4 5 **(Coping)** 5) Because your friends pressurized you to do it? 1 2 3 4 5 6) Because you would like to belong to a certain circle of friend? 1 2 3 4 5 7) To be liked by others? 1 2 3 4 5 8) To not feel excluded? 1 2 3 4 5 **(Conformity)** 9) Because it gives you a pleasant feeling? 1 2 3 4 5 10) Because it is exciting? 1 2 3 4 5 11) To experience a feeling of exaltation? 1 2 3 4 5 12) Simply because it is fun? 1 2 3 4 5 **(Enhancement)** 13) To come into contact with others? 1 2 3 4 5 14) Because it is fun to be in contact with others? 1 2 3 4 5 15) To improve your contact with friends and acquaintances? 1 2 3 4 5 16) To share a special occasion with friends? 1 2 3 4 5 **(Social)**
(Problematic Social Media Use) Thinking about your social media use in the last 12 months, what is the extent to which you agree with each of the items, items are rated on a 8-point scale (1=definitely disagree to 8= definitely agree). Please Use "✓" or circle to indicate your choice **Total scores (15-120)** **Higher scores on the scale indicate higher levels of PSMU.**	1) I have used social media to talk with others when I was feeling isolated 1 2 3 4 5 6 7 8 2) I would feel lost if I was unable to go on social media 1 2 3 4 5 6 7 8 3) I have difficulty controlling the amount of time I spend on social media 1 2 3 4 5 6 7 8 4) I prefer online social interaction over face-to-face communication 1 2 3 4 5 6 7 8 5) My social media use has made it difficult for me to manage my life 1 2 3 4 5 6 7 8 6) I have used social media to make myself feeling better when I was down 1 2 3 4 5 6 7 8 7) When offline, I have a hard time trying to resist the urge to go on social media 1 2 3 4 5 6 7 8 8) My social media use has created problems for me in my life 1 2 3 4 5 6 7 8 9) I find it difficult to control my social media use 1 2 3 4 5 6 7 8 10) Online social interaction is more comfortable for me than face-to-face interaction 1 2 3 4 5 6 7 8 11) I have used social media to make myself feel better when I've felt upset 1 2 3 4 5 6 7 8 12) When I haven't been on social media for some time, I become preoccupied with the thought of going on social media 1 2 3 4 5 6 7 8 13) I have missed social engagements or activities because of my social media use 1 2 3 4 5 6 7 8 14) I think obsessively about going on social media when I am offline 1 2 3 4 5 6 7 8 15) I prefer communicating with people online rather than face-to-face 1 2 3 4 5 6 7 8
How long do you spend using social media on an average school day?	_____ Minutes
How long do you spend using social media on an average weekday?	_____ Minutes
On school days, when do you use social media the most?	☐ No use ---- 0

	☐ Morning before school ----- 1
	☐ During school time ----- 2
	☐ After school ---- 3
	☐ Later in the evening, before sleep ---- 4
On weekend days, when do you use social media the most?	☐ No use ---- 0
	☐ Morning ---- 1
	☐ During the day ---- 2
	☐ Early evening ---- 3
	☐ Later in the evening, before sleep ---- 4
How often do you check or update your social media accounts?	☐ Almost constantly (every 1-2 hours) ---- 1
	☐ Several times a day ---- 2
	☐ Around once-a-day ---- 3
	☐ Several times a week but not every day ---- 4
	☐ Weekly ---- 5
	☐ Monthly ---- 6
	☐ Never ---- 7
	☐ Other (please specify)_____ ---- 8 not sure
	☐ Yearly ----- 9
How often do you post on social media?	☐ Almost constantly (every 1-2 hours) ---- 1
	☐ Several times a day ---- 2
	☐ Around once-a-day ---- 3
	☐ Several times a week but not every day ---- 4
	☐ Weekly ---- 5
	☐ Monthly ---- 6
	☐ Never ---- 7
	☐ Other (please specify) _____ ---- 8 not sure
	☐ Yearly ----- 9
What types of things do you most often post to social media? (Please select up to 3)	☐ Information related to your daily activities (such as food, going out, school, sport) post_of_types_sm___1 0=no 1=yes
	☐ Information about yourself (such as selfies, updates on your mood/feelings, or activities) post_of_types_sm___2 0=no 1=yes
	☐ Information related to your friends, family or pets (such as images, videos) post_of_types_sm___3 0=no 1=yes
	☐ News information (such as news headlines, updates on weather) post_of_types_sm___4 0=no 1=yes
	☐ Entertainment information (such as music, sport, memes, videos, gaming) post_of_types_sm___5 0=no 1=yes
	☐ Health information (exercise, workouts, recipes, diets, supplements) post_of_types_sm___6 0=no 1=yes
	☐ N/A post_of_types_sm___7 0=no 1=yes
	☐ Other (please specify)_____ post_of_types_sm___8 0=no 1=yes
How do you most often share your posts to social media? (please select up to 3)	☐ Stories share_of_types_sm___1 0=no 1=yes
	☐ Images share_of_types_sm___2 0=no 1=yes
	☐ Videos share_of_types_sm___3 0=no 1=yes
	☐ Text share_of_types_sm___4 0=no 1=yes
	☐ Memes share_of_types_sm___5 0=no 1=yes
	☐ N/A share_of_types_sm___6 0=no 1=yes
	☐ Other (please specify)_____ share_of_types_sm___7 0=no 1=yes
Which types of posts do you most often access? (Please select up to 3)	☐ Information related to your daily activities (such as food, going out, school, sport) look_at_sm___1 0=no 1=yes
	☐ Information related to yourself (images, mood/feelings, or activities) look_at_sm___2 0=no 1=yes
	☐ Information related to your friends, families or pets (such as images and videos) look_at_sm___3 0=no 1=yes
	☐ News information (such as news headlines, updates on weather) look_at_sm___4 0=no 1=yes
	☐ Entertainment information (such as music, sport, memes, videos, gaming) look_at_sm___5 0=no 1=yes
	☐ Health information (exercise advertisement, workout vedio, health recipes, diets, supplements) look_at_sm___6 0=no 1=yes
	☐ Other (please specify)_____ look_at_sm___7 0=no 1=yes

On your main social media account, are the accounts you follow mainly related to? (please select only one)	☐ Your friends ---- 1 ☐ Similar people your age, but not necessarily friends ---- 2 ☐ Your family ---- 3 ☐ Pets ---- 4 ☐ News (such as official sources of information) ---- 5 ☐ Entertainment (music, sport, memes, videos, gaming – including celebrities or influencers) ---- 6 ☐ Health (such as personal trainers, and including celebrities or influencers) ---- 7 ☐ Other (please specify)_____ ---- 8
What are your main reasons for using social media? **Please consider each of the reasons listed and rate whether the reason for using social media applies to you. A rating of "1" means this is not at all a reason totally why you use social media; a rating of "5" means this is sometimes a reason why you use social media; and a rating of "10" means this is very frequently a reason why you use social media. Please Use "✔" or circle to indicate your choice**	☐ To share my daily activities 1 2 3 4 5 6 7 8 9 10 ☐ To share information about me 1 2 3 4 5 6 7 8 9 10 ☐ To talk to and check in with my friends and family 1 2 3 4 5 6 7 8 9 10 ☐ To access information on the news 1 2 3 4 5 6 7 8 9 10 ☐ To acess information related to entertainment (e.g.music, sport, memes, videos or gaming) 1 2 3 4 5 6 7 8 9 10 ☐ To access health information (e.g.workout video, health recipes, diets, supplements) 1 2 3 4 5 6 7 8 9 10 ☐ Other _____ (Please specify) 1 2 3 4 5 6 7 8 9 10
Could you please check your mobile phone now, please write down your average daily screen time on your mobile phone for the past week.	_____ hours _____ minutes
Could you please check your mobile phone now, please write down the top 3 applications you have used in the past week. 1) _____ 2) _____ 3) _____	
Your feeling	
(Rosenberg-Self-Esteem-Scale)There are four possible answers for each of the 10 questions, from "strongly agree" to "strongly disagree". Use "✔" to indicate how strongly you agree or disagree with each statement **Total scores (0-30)** **Higher scores--Higher self-esteem** < 15 low self-esteem 15-25 normal range >25 high self-esteem	1. I feel that I'm a person of worth, at least on an equal plane with others rosenberg1 2. I feel that I have a number of good qualities 3. I am able to do things as well as most other people 4. I take a positive attitude toward myself 5. On the whole, I am satisfied with myself (Strongly agree=3, Agree=2, Disagree=1, Strongly agree=0) 6. All in all, I am inclined to feel that I am a failure 7. I feel I do not have much to be proud of 8. I wish I could have more respect for myself 9. I certainly feel useless at times 10. At times, I think I am no good at all (Strongly agree=0, Agree=1, Disagree=2, Strongly agree=3)
(Social Comparison Rating Scale-SCR) "When I compare myself to my peers and friends on social media, I feel...". Please Use "✔" to indicate your answer on each line according to your feeling. **Total scores (11-110)** **Higher scores--More positively compare oneself with others while using social media**	Inferior 1 2 3 4 5 6 7 8 9 10 Superior Incompetent 1 2 3 4 5 6 7 8 9 10 More competent Unlikeable 1 2 3 4 5 6 7 9 10 More likeable Left out 1 2 3 4 5 6 7 8 9 10 Accepted Different 1 2 3 4 5 6 7 8 9 10 Same Untalented 1 2 3 4 5 6 7 8 9 10 More talented Weaker 1 2 3 4 5 6 7 8 9 10 Stronger Unconfident 1 2 3 4 5 6 7 8 9 10 More confident Undesirable 1 2 3 4 5 6 7 8 9 10 More desirable Unattractive 1 2 3 4 5 6 7 8 9 10 More attractive An outsider 1 2 3 4 5 6 7 8 9 10 An insider
Mental wellbeing	
(SWEMWS) Below are some statements about feelings and thoughts. Please select the option that best describes your experience of each over the last 2 weeks (Use "✔" to indicate your answer) **Total scores (7-35)** **Higher scores--Better wellbeing** <= 17 probable depression 18-20 possible depression 21-27 average mental wellbeing 28-35 high mental wellbeing	1. I've been feeling optimistic about the future 2. I've been feeling useful 3. I've been feeling relaxed 4. I've been dealing with problems well 5. I've been thinking clearly 6. I've been feeling close to other people 7. I've been able to make up my own mind about things (1=None of the time 2=Rarely 3=Some of the time 4=Often 5=All of the time)

(6-KADS Depression) How often have you been bothered by the following problems? (Use "✔" to indicate your answer) **(1=Not at all 2=Several days 3=More than half the days 4=Nearly every day)** **Total scores (0-18) >6 means depressive symptoms**	1. Feeling nervous, anxious or on edge 2. Not being able to stop or control worrying 3. Worrying too much about different things 4. Trouble relaxing 5. Being so restless that it is hard to sit still 6. Becoming easily annoyed or irritable 7. Feeling afraid as if something awful might happen (1=Not at all 2=Several days 3=More than half the days 4=Nearly every day)
(GAD-7 Anxiety) How have you been "on average" or "usually" regarding the following items: 0=hardly ever 1=Much of the time 2=Most of the time 3=All of the time (Use "✔" to indicate your answer) **Total scores (0-21)** **0-4: minimal anxiety** **5–9: mild anxiety** **10–14: moderate anxiety** **15–21: severe anxiety**	1. Low mood, sadness, feeling blah or down, depressed, just can't be bothered 2. Feelings of worthlessness, hopelessness, letting people down, not being a good person 3. Feeling tired, feeling fatigued, low in energy, hard to get motivated, have to push to get things done, want to rest or lie down a lot 4. Feeling that life is not very much fun, not feeling good when usually (before getting sick) would feel good, not getting as much pleasure from fun things as usual (before getting sick) 5. Feeling worried, nervous, panicky, tense, keyed up, anxious 6. Thoughts, plans or actions about suicide or self-harm (0=hardly ever 1=Much of the time 2=Most of the time 3=All of the time)
Sleep	
What time do you go to bed?	On school nights: _____PM On weekends: _____PM
What time do you get out of bed?	On school days: _____AM On weekends: _____AM
How long does it take you to fall asleep?	☐ 20 minutes or less ---- 1 ☐ 40 minutes or less ---- 2 ☐ 1 hour or less ---- 3 ☐ More than 1 hour ---- 4
How many times do you wake up in the middle of the night?	_____ times, on average
(Adolescent Sleep Hygiene Scale-ASHS) During the past month, how often the following things have happened. Use "✔" to indicate your answer. (Never – has not happened; Once in A while – happened 20% of the time Sometimes – happened 40% of the time; Quite Often – happened 60% of the time; Frequently, if not always – happened 80% of the time; Always – happened 100% of the time) **Total scores (66-6)** **Higher scores=higher quality of sleep**	1. I go to bed and think about things I need to do 2. I go to bed and replay the day's events over and over in my mind 3. I check my clock several times during the night 4. During the 1 hour before bedtime, things happen that make me feel strong emotions (sadness, anger, excitement) 5. I go to bed feeling upset 6. I go to bed and worry about things happening at home or at school 7. During the 1 hour before bedtime, I do things that make me feel very awake (e.g., playing video games, watching TV, talking on the telephone) 8. I go to bed and do things in my bed that keep me awake (e.g., watching TV, reading) 9. I use my bed for things other than sleep (e.g., talking on the telephone, watching TV, playing video games, doing homework) 10. During the day, I take a nap that lasts > 1 hour 11. After 6:00 pm, I take a nap (Never – 1; Once in A while – 2; Sometimes – 3; Quite Often – 4; Frequently, if not always - 5; Always – 6)
Physical activity	
Over past 7 days, on how many days were you physical activity active for a total of at least 60 minutes? **Add up all your time spent in physical activity each day (do not include physical education or gym class)** **Recommendation of 60 minutes or more of moderate-to-vigorous physical activity daily in adolescents**	0=0 day 1=1 day 2=2 days 3=3 days 4=4 days 5=5 days 6=6 days 7=7 days
(Godin Leisure-Time Exercise questionnaire) During a typical 7-day period (a week), how many times on the average do you do the following kinds of exercise for more than 15 minutes during your free time (write on each line the appropriate number) **24 units or more = Active** **14 – 23 units = Moderately Active** **Less than 14 units = Insufficiently Active/Sedentary**	STRENUOUS EXERCISE (HEART BEATS RAPIDLY) (e.g., running, jogging, rope skipping, football, basketball, cross country skiing, taekwondo, roller skating, vigorous swimming, vigorous long-distance bicycling) _____ Times per week MODERATE EXERCISE (NOT EXHAUSTING) (e.g., Fast walking, baseball, tennis, easy bicycling, volleyball, badminton, Ping-Pong, easy swimming, Kungfu, climbing mountain, popular and folk dancing) _____ Times per week

	MILD/LIGHT EXERCISE (MINIMAL EFFORT) (e.g., Yoga, Tai Chi, fishing from riverbank, broadcast gymnastics, easy walking) _____ Times per week
Now, please open WeChat, enter "WeChat Sports", pull down the scroll bar to find all the records of the previous week, please write down the average daily steps in the previous week.	_____ Steps

8.3 Appendix 3

Appendix 3 Interaction analysis in physical activity outcomes and social media use in different genders and ages

	Interaction analysis in physical activity outcomes and social media use in different genders					
	The number of days being physically active for 60+ minutes			**Weekly leisure physical activity time**		
	Gender (Female vs. Male)			**Gender (Female vs. Male)**		
	IRR	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
Social media time 0h	Ref			Ref		
Social media time 0-1h	0.94	0.89, 1.00	0.04	2.01	1.58, 2.54	<0.0001
Social media time 1-2h	0.90	0.83, 0.96	0.003	1.36	1.01, 1.82	0.042
Social media time >2h	0.94	0.83, 1.07	0.38	2.22	1.19, 4.14	0.012

	Interaction analysis in mental health outcomes and social media use in different ages					
	The number of days being physically active for 60+ minutes			**Weekly leisure physical activity time**		
	Age groups (14-15 years old vs. 12-13 years old)			**Age groups (14-15 years old vs. 12-13 years old)**		
	IRR	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
Social media time 0h	Ref			Ref		
Social media time 0-1h	0.86	0.82, 0.91	<0.0001	1.74	1.40, 2.16	<0.0001
Social media time 1-2h	0.85	0.79, 0.91	<0.0001	1.46	1.09, 1.95	0.01
Social media time >2h	0.77	0.67, 0.88	<0.0001	1.32	0.79, 2.20	0.28

8.4 Appendix 4

Appendix 4 Focus group discussion topic guide

> *Section one: Social Media Definition*
> 1. We want to know a little bit more about social media. So, when someone says the word "social media", what do you think of?
>   a. How would you describe social media (such as what does it do, what does it enable you to do?)
>   b. Do you think everyone your age would describe it in that way, and if so why or why not?
>
> *Section two: Social Media Use*
> 2. Why do you use social media? (or what prompts you to use)
>   a. Do you think your peers have the same reasons as you or other opinions about social media use?
>
> 3. What types of posts do you see on social media?
>   i. Could you please describe a post you have seen in the past week?
>   ii. What was the message or topic of that post?
>   iii. When did you see it? (detailed time or place)
>   iv. Where did you see it? (platforms)
>
> 4. When you post to social media, what types of posts do you share?
>   i. What are the main messages or topics of your posts?
>   ii. When do you often post? (detailed time or place)
>   iii. What social media sites do you share your posts to? (platforms)
>   iv. Could you please describe a post you have posted recently?
>
> 5. Overall, what are the main social media posts you:
>   a. Look at
>   b. Share/re-share
>   c. Post/Create
>   d. And why
>
> *Section Three: Social Media and Physical Activity*
> 6. To what extent does your uses of social media affect your engagement with physical activity?
>   a. Types or forms of physical activity
>   b. Time you engage with physical activity
>
> 7. Does social media prompt you to engage with physical activity, how and why or why not?
>
> 8. What types of social media posts do you consider to be most or least influential in relation to your engagement with physical activity?
>   a. Do they help you learn of different types of movements?
>   b. Do they prompt you to increase the amount of time you engage with physical activity each day?

c. Do they help you to develop your movement skills to engage with physical activity, such as improved fitness, muscular, or overall body shape and size?

d. Overall, what influences you the most to engage in physical activity, is it social media or something else in your life, and why?

9. We want to know a little bit more about the types of social media posts that are influential for you and/or young people your age, can you describe:
   a. What types of social media posts you see related to physical activity on social media?
   b. What makes you or other people your age stop and look at a post?
   c. What makes you or other people your age act on a particular post?
   d. Are there any accounts, individuals or contexts that are influential?
      i. Social media platforms
      ii. Peers
      iii. Celebrities
   e. How does what you access from social media compare to other sources or prompts for physical activity, such as school, PE, friends, family etc?

10. Do you post/share to social media, or have you previously, about something related to physical activity?
    a. Can you describe the post?
    b. Can you explain why you shared the post?

11. Overall, do you think social media is a useful prompt for physical activity for young people your age?
    a. What are the advantages?
    b. What are the drawbacks?
    c. What are the opportunities?

12. We have mainly talked about the advantages and positives to social media, do you think there are any drawbacks?
    a. E.g. does the time you spend on social media limit the time you have to engage with physical activity, and why?
    b. Are there any types of social media posts that make you less likely to engage with physical activity?
    c. If it has no influence on your physical activity engagement, why is that?

Section Four: Summary
13. Young people are generally positive about social media as an aspect of their lives, can you explain whether you think that to be true for you
    a. And in relation to physical activity

14. Many adults are worried about young people's uses of social media,
    a. why do you think that is?
    b. Should they be worried and why?

15. For young people your age using social media and in relation to physical activity, can you give three recommendations for them, and explain why? For example in relation to
    a. The content you see
    b. The accounts that share information
    c. Your peers' posts
    d. The time you spend on social media
    e. Young people your age reasons for using social media
    f.

Supplement--Any questions you would like to share and discuss?

8.5 Appendix 5

Appendix 5 Codebook of the focus groups

No.	Name of Codes	Description of codes
General Social Media Use		
1.	Arriving home to report safety	Using social media features such as video calls to report home arrivals
2.	Spreading negative emotions	The content on social media is not so positive and many adolescents see that it can easily lead to sadness
3.	Kill time	Social media helps adolescents pass the time for leisure and entertainment
4.	Control over the type and timing of social media use	Parents control the frequency, timing and type of adolescents' social media use
5.	Influence on physical health	Excessive use of social media can lead to effects on physical health, such as (cervical spondylosis & bad for eyesight)
6.	Crime on social media	Crimes on social media (deception, theft of information, etc.)
7.	Use of a variety of functions	Social media is versatile, offering video calls, memes, emoji, motion pictures and more
8.	Relaxing	Social media can help adolescents relax and unwind
9.	Puppy love	Parents may worry adolescents may fall in love early
10.	Conservative attitude towards social media	Parents remain conservative in their thinking about social media, believing that it may be a bad influence on their children
11.	Show myself	Adolescents can show their profile on social media
12.	More applications	Social media contains a wide variety of apps can provide more functions
13.	QQ	QQ, short for Tencent QQ, is an Internet-based instant messaging software launched by Tencent
14.	TikTok	TikTok is a short-form social video application that can be viewed on smartphones and is operated by China's ByteBeat Corporation
15.	WeChat	WeChat is an instant messaging software launched by Tencent on January 21, 2011, which supports Android and iOS mobile operating systems and is aimed at smartphone users. Users can share text, pictures and stickers with their friends through the client, and support group chat and voice, photo/video sharing, location sharing, message exchange and contact, WeChat payment, games and other services

No.	Name of Codes	Description of codes
16.	Express yourself freely	The anonymity of social media allows adolescents to express themselves more uninhibitedly on social media
17.	Communications	Social media helps adolescents better communicate and interact on a daily basis
18.	Chatting	Adolescents like chatting on social media
19.	Addicted to social media	Adolescents may over-indulge in social media
20.	Record my life	Use social media to record the memorable moments in adolescents' lives
21.	Make bad friends	Social media has a wide range of people, and adolescents may make bad friends
22.	Make friends	Social media is a channel to make friends
23.	Turn on traceless browsing	When browsing social media, adolescents don't want others to see their browsing history, they may turn on the unmarked browsing history
24.	Popular science	You can see a lot of science articles on social media
25.	Borden my horizon	Social media can help people learn about people and things in the outside world and enrich their lives and eyes
26.	Satisfy my curiosity	There is always something new and exciting in social media to satisfy people's curiosity
27.	Follow the celebrities' accounts	Adolescents will follow the social accounts of celebrities on social media
28.	Follow the celebrities' dynamics	Adolescents may focus on the celebrities' dynamics on social media
29.	Internet celebrities	Internet celebrities are the major segment that adolescents may focus on social media
30.	Sharing posts	Share and spread other people's posts about PA on social media allows more people to see them
31.	Block somebody	When adolescents don't want to share their social media activity with a certain group of people, they will choose to block some adolescents
32.	Invade privacy	Social media may be at risk of compromising personal privacy
33.	Disclosure of personal information	Risk of personal information disclosure on social media
34.	Different personalities	Adolescents may show the different personalities on social media than they do in their daily lives

No.	Name of Codes	Description of codes	
35.	Current events update	News and current events showing on social media	
36.	Use extra social media account	Some adolescents use additional social media accounts because of privacy concerns	
37.	Vent of mood	Social media provides a platform to express oneself by venting emotions	
38.	Date online	Meet and fall in love with somebody on social media	
39.	Maintain relationships	Stay connected and maintain relationships with others on social media	
40.	Have a bad impact on study	Parents may worry about social media interfering with learning	
41.	Play games	Play games on social media	
42.	Watch Anime	Watch Anime on social media	
43.	Watch Comics	Watch Comics on social media	
44.	Read novels	Read novels on social media	
45.	Browse TikTok	Browse TikTok	
46.	Listen to music	Listen to music on social media	
47.	Watch series	Watch series on social media	
48.	Show and Share Life	You can show your life and dynamics on social media to others	
49.	Gossip talking	Adolescents can often gossip together on social media	
Social Media Use in Relation to PA			
50.	The blogger is not in good figure	Many PA bloggers on social media are in poor figure themselves and are unconvincing	
51.	The good figures may not real	The good figure shown in the video and pictures may not be true, there is the possibility of embellishment	
52.	Lots of bad comments	Many social media posts about PA may include a lot of negative comments	
53.	Practice for a while, but no effect	Using social media PA content to practise PA but not seeing any result after a period of time	
54.	Unreliable content	The content of many posts about PA are exaggerated or unreliable	
55.	Live Streaming related to PA	Some bloggers on social media play a role of commentator in PA events and sports matches, these contents are very attractive	

No.	Name of Codes	Description of codes
56.	Not being able to learn systematically	Physical education on social media lacks a systematic approach, rarely follows a step-by-step process, and does not plan for each individual's different situation
57.	Different knowledge of PA	Social media exposes us to a different kind of PA knowledge
58.	Unprofessional guidance	Advice and guidance on PA on social media may not be professional enough
59.	Blind imitation may be injured	Physical activity videos on social media may lead to blind imitation; blindly imitating the content that PA related may cause hurts
60.	Pursue of a strong body	The good figure shown to adolescents on social media has inspired the pursuit of a good figure
61.	Pursue of physical health	The good figure and healthy lifestyle shown to adolescents on social media has inspired the pursuit of a healthy body
62.	Admire a perfect figure	The good figure shown to adolescents on social media has aroused the envy of a good figure
63.	Repeated viewing possibilities	Content about PA on social media can be viewed repeatedly
64.	Abundant sports resources	Social media includes a wealth of PA resources, pictures, texts, videos, etc.
65.	Interested PA programme	Social media will push notifications related to PA that are of interest to everyone
66.	The efficient ways to exercise	Social media will provide some new ideas on how to do PA more efficiently
67.	More vivid videos and pictures	Social media includes a wealth of PA resources, pictures, texts, videos, etc.
68.	Too many advertisements	The overwhelming number of adverts on social media makes it very easy to be distracted from sports content
69.	Too much choice to be confused	Social media do offer youth a lot of options for PA material, but the plethora of choices is also really dizzying
70.	Active encouragement and promotion	Adolescents have access to a lot of content on social media about encouraging more engagement in PA
71.	Skills of PA	PA resources on social media teach a lot of content about sports skills
72.	Lose weight	There is a lot of content on social media about weight loss
73.	Just save some content, but not taking real action	For social media posts about PA, many people just collect them and do not practice them in time

No.	Name of Codes	Description of codes
74.	Inability to follow up progress	It is possible to learn and practice PA on social media, but the lack of supervision makes it difficult to follow up on learning progress
75.	The exact time for achieving good effects	Social media content about PA is more attractive when it gives a clear time frame to achieve good results
76.	Endorsements and support from reviews	Positive comments and support from viewers in the PA-related posts will make the posts look more authentic and attractive
77.	Impacts from celebrities	Adolescents are easily influenced to respond positively to PA by celebrity sports activities
78.	Celebrity endorsement	Many sports events and PA products that have celebrity endorsements are more attractive
79.	Celebrities-related documentary films	Adolescents are often inspired and encouraged by the various sports celebrity documentaries they can see on social media
80.	Famous sports celebrities	Adolescents can often see various sports celebrities on social media
81.	The company and encouragement of friends	Friends can accompany you doing PA together or give you encouragement when you may not feel so keen to do PA
82.	Communication and interaction in posts	Lively discussions in PA-related posts
83.	Other interesting content distracts from PA	Social media is full of other interesting content that can easily distract adolescents' attention from sports
84.	More cost effective	Cheaper and more cost-effective physical education offered on social media
85.	Stimulates the idea of competition	Adolescents may see a variety of PA resources and fellow PA posts on social media, and unconsciously they want to try and compare themselves with them
86.	PA clock-in	Adolescents make a record when they do PA and post it on social media everyday
87.	Ranking and likes in WeChat Sport	WeChat Sports is a public account similar to a pedometer database developed by Tencent. Users can follow WeChat Sports public account to check the number of steps they walk every day, and also compare their PA with other users or give them likes. The ranking and likes in there motivate adolescents to want to compete with other social media friends
88.	Using WeChat Sport	WeChat Sports is a public account similar to a pedometer database developed by Tencent. Users can follow WeChat Sports public account to check the number of steps they walk every day, and also compare their PA with other users or give them likes.

No.	Name of Codes	Description of codes
89.	An app called Keep	Keep is a fitness app developed by Beijing Calorie Technology Co. Launched in February 2015, it contains fitness teaching, running, cycling and other functions.
90.	More autonomy and choices	Social media offers adolescents more autonomy and choice in PA resources and contents
91.	The high quality of the PA content	The high quality of the PA content (lengths, contents, colour, special effects, and so on) may improve the PA learning attraction.
92.	Sport match	Famous sports events broadcast on social media attract adolescents' attention
93.	Peers' encouragement	Adolescents often see posts about PA from peers on social media and feel encouraged
94.	Novel and niche PA	Social media will push notifications related to PA that are very novel and niche
95.	Virtual PA	Adolescents can follow the bloggers who do live PA on social media, and many viewers can communicate with the bloggers and do PA together, even in different places
96.	Many movements may be difficult to render	Many of the PA shown on social media may only be video effects, which are difficult to render in reality
97.	Choose professional PA accounts	Choose a more professional and credible account on social media
98.	Supervision and support on PA from parents	Parents ask or company adolescents to do physical activity in routine life
99.	Supervision and support on PA from schools	The school and teachers supervise and organise the physical activity of adolescents
100.	Provide better security for physical activities	Schools can provide better security for physical activities, such as warm-ups, to keep everyone as safe as possible
101.	Lively PA atmosphere	PA in school means more adolescents join in together, the atmosphere will be lively and enjoyable
102.	Systematic guidance	Physical education learning in schools will provide more systematic guidance
103.	Showing the explicit effects	The videos and pictures related to PA on social media show a clear change before and after the PA
104.	Attractive titles	Many contents related to PA articles, videos, etc. on social media have attractive titles

No.	Name of Codes	Description of codes
105.	Hard to insist doing PA	Some of the PA resources on social media are difficult to used and do not contain detailed explanation, it is not easy keep learning the PA skill
106.	Meet like-minded partners	Social media allows adolescents to reach out to more like-minded friends in sports
107.	PA clock-in (school)	The teacher asks everyone to do PA clock-in on WeChat Group, i.e., upload a video or photo of themselves doing PA
108.	Showing off PA achievements	Social media where adolescents can show the results of your PA and the exercise process (pictures and videos)
109.	PA challenges	Some bloggers often start a challenge for a particular PA on social media, which can make adolescents very passionate about joining in
110.	Famous sports brands	The presence of various well-known sports brands can often be seen on social media
111.	Physical education examination items	adolescents pay attention to PA items related to the high school entrance exam
112.	The clear effects shown by the surrounding people	The people around adolescents show obvious outcomes through doing PA using content provided by social media
113.	Learn and practice PA at home at any time	Social media gives the opportunity to everyone to learn and practise PA at home anytime

Note: PA = physical activity

8.6 Appendix 6

Appendix 6 Theme table of focus groups in general social media use

Themes	Subthemes	Categories	Codes
Social media functions and potential problems *It refers to adolescents how to use of social media in their routine life and reflects some of their motivations why they using social media. Meanwhile, some potential problems with social media use also be pointed out.*	*Enrich after school life* Boys seem to regard playing games as a part of their life, they seem to always play games all the time and feel that games are very important. Playing games for girls to kill time or to entertain (FG7, Girl 1, age 14-15, school 2). Many people probably use it [social media] for entertainment. After finishing homework or tasks, they will use this method to have fun, often swiping Douyin for an hour (FG2, Boy 2, age 12-13, school 1).	*Idol chasing;* Because this way (on social media) you can get closer to your idols (FG3, Girl 3, 14-15 years old, school 1) On some social media platforms, you can learn about the latest developments of the star, such as what live shows or series he is going to release, as well as his schedule. You can watch it on social media in [real] time because if there is no such platform, you can only rely on TV by chance (FG5, Girl 6, age 12-13, school 2).	Follow the celebrities' accounts, Follow the celebrities' dynamics, Internet celebrities
		Entertainment/relaxation; Just play games when you're bored (FG8, Boy 6, 14-15 years old, school 2) Many people probably use it for entertainment. After finishing homework or tasks, they will use this method to have fun, often swiping Douyin for an hour (FG2, Boy 2, 12-13 years old, school 1)	More applications, Use of a variety of functions, QQ, WeChat, TikTok, Chatting, Popular science, Play games, Watch Anime, Watch Comics, Read novels, Browse TikTok, Listen to music, Watching series, Date online, Maintain relationships, Make friends, Kill time, Relaxing, More applications, Borden my horizon, Satisfy my curiosity, Current events update

	Concerning Social Media Privacy Considerations I have two QQ accounts, and I don't post very often on the main account. Sometimes when I'm in a bad mood, I often post some posts and then delete these posts on my main account. Whereas if my complaints posted on another account that means no one will notice (FG3, Girl 1, age 14-15, school 1).	*(Pros) Be freer in privacy* Sometimes, for example, when I am in a bad mood, I will go to social media to express myself. Anyway, they don't know me, and then I say something, and then I have no scruples (FG2, Boy 4, age 12-13, school 1).	Block somebody, Express yourself freely, Use extra social media account, Vent of mood, Turn on traceless browsing, Different Personalities on social media and real life
		(Cons) Invasion of privacy But there is also a downside to telling secrets to others on QQ, that is, others may tell my mother and violate my privacy (FG1, Girl 5, age 12-13, school 1). But social media also has shortcomings. For example, your usual privacy is easy to be leaked and exposed (FG7, Girl 2, age 14-15, school 2)	Invade privacy, Crime on social media, Disclosure of personal information

		Potential worries from social media use	*Negative element exposure*	Puppy love, Conservative attitude from parents towards social media, Have a bad impact on study, Make bad friends, Addicted to social media, Control over the type and timing of social media use, Influence on physical health (Cervical spondylosis, Bad for eyesight), Crime on social media
		Some adults are more worried about their children playing games, because that kind of game, for example, the glory of the king, once the game starts, at least last for one hour, once the game starts, it lasts for at least one hour delaying the time for homework and study (FG7, Girl 4, age 14-15, school 2).

When we may have the possibility to be deceived when meeting social media friends. Also, there are people who go online to date and get scammed (FG1, Girl 3, age 12-13, school 1). | The reason my parents were worried about me using social media was because they were afraid I would fall in love early (FG4, Boy 2, 14-15 years old, school 1)

Some adults are more worried about their children playing games, because that kind of game, for example the glory of the king, once game starts, at least last for one hour, delaying the time for homework and study (FG7, Girl 4, 14-15 years old, school 2) | |
| | | The reason my parents were worried about me using social media was because they were afraid of I would have puppy love (FG4, Boy 2, age 14-15, school 1). | *Safety supervision*

Social media has the role of supervision. Now with QQ and WeChat, my mother said that when I got home, give her a video call and let her see if I am safe at home (FG7, Girl 4, age 14-15, school 2). | Arriving home to report safety |

8.7 Appendix 7

Appendix 7 Theme table of focus groups in social media use in relation to physical activity

Themes	Subthemes	Categories	Codes
Based on its the strong and various features, social media supports the PA involvement among adolescents multi-directionally. Whereas it also has its own drawbacks compared with other means			
Interactions *In relation to physical activity, social media provides opportunities for interactions relating to competition and the encouragement of physical activity behaviours. Adolescents could compete with their social media friends and be encouraged to engage with physical activity by celebrities. Furthermore, adolescents could access sport-related content from social media that increased their understanding of sports*	**Competition on social media** I use WeChat Sport. Every day I see how many steps I can take and how many rankings I can rank. I want to be the first, and I have a mentality of wanting to compete with others (FG6, Boy 6, age 12-13, school 2).	***Competition on social media*** I use WeChat Sport. Every day I see how many steps I can take and how many rankings I can rank. I want to be the first, and I have a mentality of wanting to compete with others (FG6, Boy 6, age 12-13, school 2).	Stimulates the idea of competition, Ranking and likes in WeChat Sport, PA challenges, Pursue of a strong body, Pursue of physical health, Admire a perfect figure
		Share their PA achievements on social media Sometimes when I run, the screenshot of the step count will be posted to the QQ feed, and I will feel proud when I feel like showing off (FG6, Boy 4, age 12-13, school 2). And social media also provides you with a platform, you can post it for more people to see, and then everyone thinks you are cool (FG2, Boy 3, age 12-13, school 1).	PA clock-in, showing off PA achievements

	Sense of community	Peer encouragement	The clear effects shown by the surrounding people, Meet like-minded partners, Peers' encouragement, The company and encouragement of friends
through further discussion with others on social media. Meanwhile, positive interactions such as showing one's physical activity performance on social media also encouraged adolescents to do more physical activity. These key features of interactions through social media will be explored in this sub-section.	You can be encouraged to exercise by the people around you, if you exercise by yourself at the beginning, because of just yourself, you may not insist on exercising. Then if you meet two or three people you meet good friends on social media, everyone will If you exercise together, the efficiency will be better (FG 5, Girl C, aged 12-13, school 2)	I think it [social media] will have a certain encouragement relationship, because if one of the two people doesn't want to do it, and the other wants to continue, then that one will pull me to do it together (FG3, Girl 3, age 14-15, school 1). I didn't exercise myself before, and then I saw that others were exercising on social media, and there was a feeling that everyone else was exercising, why should I sit here and so on, forming a feeling of following the trend (FG8, Boy 1, age 14-15, school 2).	
		Encouragement from celebrities I think there are many stars playing basketball. For example, Kobe Bryant passed away, but Kobe's Mamba spirit has always lived on in the world, and it has inspired generations of teenagers who are willing to do these basketball sports. (FG5, Girl 1, age 12-13, school 2). I saw my idol on Weibo, I forgot when, and then he posted a picture of himself playing basketball, that is so handsome, and then I would have the urge to learn to play basketball too (FG2, Girl 6, aged 12-13, school 1).	Famous sports brands, Impacts from celebrities, Celebrity endorsement, Celebrities-related documentary films, Live Streaming related to PA, Sport match, Famous sports celebrities

		Endorsements by audiences There must be people who comment below, and then there are many people who support it, and you can see that everyone in the audience can personally experience it. The kind that everyone shares with success stories (FG1, Girl 5, age 12-13, school 1).	Endorsements and support from reviews, Showing the exact effects
		Interactions with social media posts You can comment something under the posting, and then a lot of people can interact and exchange the experience of the movement (FG4, Boy 4, age 14-15, school 1). Go to communicate with other athletes on the Internet, how to exercise, and promote our exercise, they may record their exercise methods, we can follow and learn (FG8, Boy 4, age 14-15, school 2).	Communication and interaction in posts, Sharing posts
Accessibility *Accessibility refers to how social media provides a platform for adolescents to locate relevant information related to PA in a timely manner. Accessibility supports that many resources related to PA are available through social media, for example,*	**Social media provides PA learning opportunities** For example, in terms of how to play table tennis, social media will tell you more skills that you can't learn normally (FG8, Boy3, aged 14-15, school 1)	*(Pros) Abundant resource* There are a lot of videos on social media that are very good for sports. You may be very resistant to do sports, but after being exposed to something from social media, you think you can try it, and then you will gradually become willing to try sports (FG3, Girl 3, age 14-15, school 1). Because now I actually have a lot of sports that I learned from the Internet instead of learning it in school. All of us are curious and eager to win, and then we see what others do and we want to do it, but you don't want to do it. Yes, you can find these	More autonomy and choices, novel and niche PA, The efficient ways to exercise, More vivid videos and pictures, Abundant sports resources, Skills of PA, Physical education examination items, Attractive titles, Different knowledge of PA, Using WeChat Sport, An app called Keep, Virtual PA, The high quality of the PA content, Lose weight, Exact time for achieving good effects, Professional PA accounts, Showing the explicit effects

information on different physical activity pursuits.		videos and pictures from social media to learn (FG 2, Boy 2, age 12-13, school 1)	
		(Pros) Suggested content related to PA [On social media] I could be able to see the PA that I like and it is in line with my hobbies and tastes (FG5, Girl F, aged 12-13, school 2) Recently, I also usually binge a lot of dancing videos on QQ, such as Wang Chongmo and his dance partner. Because I can dance Latin dance, I always pay more attention or search for related information (FG 4, Boy A, aged 14-15, school 1)	Interested PA programme, Active encouragement and promotion
		(Pros) Convenience I think the advantage is that it can better promote us to exercise. For example, we don't need to ask a professional coach to teach us these things, which saves money (FG7, Boy 5, age 14-15, school 1). Some key parts of the exercise video can be watched repeatedly, which allows us to exercise more effectively. For example, if you haven't learned a detail, you can watch it again and again (FG5, Boy 2, age 12-13, school 2).	Repeated viewing possibilities, More cost effective, learn and practice PA at home at any time
	Social media provides PA learning pitfalls The disadvantage is that some movements may be difficult to learn for a while, and it takes a lot of time and	*(Cons)Lack of interest and motivation* For example, there are some content that you don't understand, but you can't communicate with the people in the video. And sometimes learning is not very systematic, some I can learn, some I can't, and I don't know what to do (FG2, Boy 4, age 12-13, school 1).	Just save some content, but not taking real action, Inability to follow up progress, Hard to insist doing PA, A person's PA practice without motivation, Not being able to learn systematically, Too much choice to be confused, Practice for a while, but no effect

	energy, but it may not be learned, and then people may feel frustrated (FG 6, Boy 2, age 12-13, school 2)	*(Cons) Content of low credibility;* It looks good to have that kind of title, but it doesn't work. Bloggers have no real skills themselves, and what they teach may be unprofessional (FG3, Boy 1, age 14-15, school 1).	Many movements may be difficult to render, The advertisement used to selling of goods, The blogger is not in good figure, The good figures may not real, Lots of bad comments, Practice for a while, but no effect, Unreliable content, Unprofessional guidance, Blind imitation may be injured
		(Cons) Distract by other interesting content on social media; When you see a post about sports, you want to do some activity. Then sometimes we may just have a look to other entertainment activities, for example, sometimes brush to play games or something, and then indulge in this game again (FG2, Boy 3, age 12-13, school 1).	Other interesting content distracts from PA, Too many advertisements
	A preference for group exercise offline I think the school has a greater impact on us because I think doing PA at school is for everyone to do together, rather than alone, and being alone often makes us feel	*More people to exercise together, creating positive atmosphere* Because everyone, we run and exercise from one class to another, everyone shouts slogans together, there will be that kind of atmosphere, I will feel very inspirational (FG1, Girl 4, age 12-13, school 1).	Lively PA atmosphere, Systematic guidance

		More safety considerations, such as warming up, more systematic guidance	Provide better security for physical activities
	lonely, but being in a group makes us feel proud and powerful (FG 6, Boy 6, age 12-13, school 2)	For the safety of our sports, the school may let everyone warm up first (FG2, Boy 3, age 12-13, school 1).	
Supervision *Supervision refers to social media as a real-time communication tool that can be used to supervise adolescents PA behaviours by teachers and parents.*	*Social media play a role in supervision* Because the teacher wanted to urge everyone to check in for sports in the group during the pandemic, the teacher encouraged you to take a video and post it in the group, and social media is like a CCTV monitoring you. The fact is that my mother was taking pictures or videos with her phone when I was jumping the rope (FG5, Girl 2, aged 12-13, school 1).	*Supervision in PA on social media* I still remember that the teacher appealed to everyone to do PA check-in with the group during our winter vacation (FG 4, Girl A, aged 14-15, school 1)	PA clock-in (school)
		Schools and parents could provide on-site supervision and support. I think schools and parents are more able to ensure the completion of PA. For example, like those videos you swipe from social media, sometimes it is difficult to actually take action when you just think about it in your heart. But it is mandatory for parents and schools, so you can take the initiative to exercise, that is, you can get better outcomes (FG8, Boy 5, age 14-15, school 2). My dad would post some pictures on WeChat Moment of his morning run, when he arrived at a destination and then they would take a picture to represent him coming here and then there might be some comments in the posting, sometimes my dad would take me running with him, and I would be happy to do physical activity with my dad (FG7, Girl 3, age 14-15, school 2)	Just save some content, but not taking real action; Inability to follow up progress, Supervision and support on PA from parents, Supervision and support on PA from schools

Note: PA = physical activity

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