THE UNIVERSITY OF QUEENSLAND

AUSTRALIA

Physical activity, sedentary behaviour and psychological wellbeing among young adults in Bangladesh: A one-year prospective study

Riaz Uddin

BPharm(Hon's), MS

A thesis submitted for the degree of Doctor of Philosophy at

The University of Queensland in 2018

School of Health and Rehabilitation Sciences

Abstract

Background: The transition to young adulthood offers more autonomy in making lifestyle choices, many of which can be unhealthy. Lack of physical activity (PA) and prolonged sedentary behaviour (SB) can have adverse effects on the concurrent and future health and wellbeing of young adults. However, little is known about PA and SB among young adults in low-and-middle-income countries (LMICs), where rapid urban-industrial transformation may promote a sedentary lifestyle and affect wellbeing. Bangladesh is an LMIC with young adults representing one-fifth of the country's population. Major causes of poor health in this age group are attributed to non-communicable diseases and psychosocial disorders. Given the established associations with health and wellbeing, it is essential to understand PA and SB of young adults in Bangladesh.

Objectives: To assess the (i) prevalence and sociodemographic patterns of PA and SB, (ii) individual-level correlates of PA, SB, and changes in PA and SB, and (iii) associations of PA and SB with psychological distress and sleep difficulties among university-based young adults in Bangladesh.

Design and Methods: A one-year prospective study with two assessment points was conducted to collect data. The self-administered written survey included the Global Physical Activity Questionnaire (GPAQ) to assess PA and SB. Wellbeing was assessed using the Kessler 6 Psychological Distress scale and a single item on sleep difficulties. Data on sociodemographic, health, wellbeing, lifestyle, and environmental factors were also collected.

Setting/participants: Participants were undergraduate students aged 18 to 24 years from six universities (3 public and 3 private) in Dhaka city, Bangladesh (Wave 1=573; response rate 92%, 45% female; Wave 2=395).

Results: Overall, 17% of participants at Wave 1 and 23% at Wave 2 met the World Health Organization recommendations to do ≥150 mins/week of moderate-to-vigorous PA (MVPA). Significantly more males than females were meeting the recommendations at both waves (Wave 1: 27% vs. 6%; Wave 2: 34% vs. 12%). Median duration of MVPA was significantly higher ($p<.0001$) for males [120 mins/week] than females [90 mins/week]. Jogging/running was the most common recreational PA, with 20% males and 12% females doing this at least once per week. Females participated more in indoor activities (e.g.,

yoga, stationary exercise), and males did more outdoor activities (e.g., cricket, football) at Wave 1.

Overall, 45% participants at Wave 1 and 39% at Wave 2 had high SB (≥480 mins/day). More females than males had high SB at both waves (Wave 1: 52% vs. 39%; Wave 2: 46% vs. 32%). Females reported more time than males in sitting-talking and telephone time during both weekends and weekdays, and television time during weekend days, at Wave 1. Based on Wave 1 data on perceived environmental barriers to PA, poor street lighting at night (62%) and lack of convenient places for PA (56%) were the most common environmental barriers to PA. Analysis of Wave 1 data found that lack of safety and lack of convenient places were more salient to females than males.

Multivariable modelling of prospective data showed that PA efficacy and participation in organised sports were positively associated with both females and males' PA. PA outcome expectations, healthy sleep duration, life satisfaction, and increased age were positive correlates of females', but not males', PA. Being male, high phone time, and not participating in organised sports at Wave 1 were associated with a decrease in PA over one year. Prospective data modelling of SB found that female gender, increased age, studying in a public university, and living with the family were positively associated with SB.

Prospective data modelling indicated that insufficient PA (<150 mins/week) was independently associated with both distress and sleep difficulties. High SB (≥480 mins/day) was not significantly associated with either wellbeing measures. Participants with insufficient PA+high SB or insufficient PA+low SB had more distress than those with sufficient PA+low SB. Participants with insufficient PA+high SB had higher odds of often experiencing sleep difficulties than those with sufficient PA+low SB.

Conclusions: Findings suggest a high prevalence of insufficient PA and prolonged SB among university-based young adults in urban Bangladesh, in particular among females. There were gender-based differences in correlates of PA. Insufficient PA, irrespective of SB, was significantly associated with poor psychological wellbeing. Findings of this research can be instrumental in developing strategies to promote an active and healthy lifestyle among young adults in Bangladesh. Proposed initiatives include organised and weekend sports, female-friendly PA facilities at universities as well as in local residential areas, and female only gym or dedicated hours for females. Recommendations also

include government initiatives and a national PA policy for the development of infrastructures that foster healthy activity behaviours, implementation of the existing policies for active lifestyle, and investment in national surveillance. Long-term prospective research is needed with population-based representative samples, including regional and metropolitan areas, to understand the trajectory of these behaviours, and to assess the direction of associations between PA, SB and wellbeing.

Declaration by author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

I have clearly stated the contribution of others to my thesis as a whole, including statistical assistance, survey design, data analysis, significant technical procedures, professional editorial advice, financial support and any other original research work used or reported in my thesis. The content of my thesis is the result of work I have carried out since the commencement of my higher degree by research candidature and does not include a substantial part of work that has been submitted to qualify for the award of any other degree or diploma in any university or other tertiary institution. I have clearly stated which parts of my thesis, if any, have been submitted to qualify for another award.

I acknowledge that an electronic copy of my thesis must be lodged with the University Library and, subject to the policy and procedures of The University of Queensland, the thesis be made available for research and study in accordance with the Copyright Act 1968 unless a period of embargo has been approved by the Dean of the Graduate School.

I acknowledge that copyright of all material contained in my thesis resides with the copyright holder(s) of that material. Where appropriate I have obtained copyright permission from the copyright holder to reproduce material in this thesis and have sought permission from co-authors for any jointly authored works included in the thesis.

Publications included in this thesis

Uddin R, Khan A, Burton NW. (2017) Prevalence and sociodemographic patterns of physical activity among Bangladeshi young adults. *Journal of Health, Population and Nutrition* **36**:31. doi: https://doi.org/10.1186/s41043-017-0108-y – *incorporated as a part of Chapter 4 (Section 4.1)*.

Uddin R, Burton NW, Khan A. (2018) Perceived environmental barriers to physical activity in young adults in Dhaka City, Bangladesh - does gender matter? *International Health* **10**:40-46. doi: https://doi.org/10.1093/inthealth/ihx057 – *incorporated as a part of Chapter 5 (Section 5.1)*.

Submitted manuscripts included in this thesis

Uddin R, Khan A, Burton NW. Are the young adults in Bangladesh sitting too much? – *incorporated as a part of Chapter 4 (Section 4.2)*.

Uddin R, Burton NW, Khan A. Correlates of physical activity in university-based young adults in Bangladesh: A one-year prospective study. – *incorporated as a part of Chapter 5 (Section 5.2)*.

Uddin R, Burton NW, Khan A. Correlates of sedentary behaviour in university-based young adults in Bangladesh: A one-year prospective study. – *incorporated as a part of Chapter 5 (Section 5.3)*.

Uddin R, Burton NW, Khan A. What factors are associated with changes in physical activity and sedentary behaviour over one year among university-based young adults? – *incorporated as a part of Chapter 5 (Section 5.4)*.

Uddin R, Burton NW, Khan A. Combined effects of physical inactivity and sedentary behaviour on psychological distress among university-based young adults: A one-year prospective study. – *incorporated as a part of Chapter 6 (Section 6.1)*.

Uddin R, Burton NW, Khan A. Effects of physical inactivity and sedentary behaviour on sleep difficulties among young adults: A one-year prospective study. – *incorporated as a part of Chapter 6 (Section 6.2)*.

Other publications during candidature

Peer-reviewed papers

Uddin R, Khan A, Burton NW. (2017) Prevalence and sociodemographic patterns of physical activity among Bangladeshi young adults. *Journal of Health, Population and Nutrition* **36**:31. doi:10.1186/s41043-017-0108-y

Uddin R, Burton NW, Khan A. (2018) Perceived environmental barriers to physical activity in young adults in Dhaka City, Bangladesh - does gender matter? *International Health* **10**(1):40-46. doi:10.1093/inthealth/ihx057

Conference abstracts

Uddin R, Khan A, Burton NW. Sedentary behaviour of young adults in Bangladesh. *Australian Society for Medical Research QLD Postgraduate Student Conference*. Brisbane, Australia. 1 Jun. 2016.

Uddin R, Burton NW, Khan A. Physical activity of young adults in Dhaka city, Bangladesh. *1st The University of Queensland Bangladesh Association Conference*. Brisbane, Australia. 27 Sept. 2016.

Uddin R, Burton NW, Khan A. Perceived environmental barriers to physical activity in young adults in Dhaka city, Bangladesh. *Australasian Society of Behavioural Health and Medicine/Australian Psychological Society College of Health Psychologists Conference*. Gold Coast, Australia. 13-15 Jul. 2017.

Uddin R, Burton NW, Khan A. Interactive effects of physical activity and sedentary behaviour on psychological distress among young adults: a longitudinal study. *The University of Queensland School of Health and Rehabilitation Sciences Postgraduate Research Conference*. Brisbane, Australia. 22 Nov. 2017.

Contributions by others to the thesis

Associate Professor Asaduzzaman Khan (primary advisor) and Dr Nicola W Burton (co-advisor) provided assistance with the original concept and design of the overall thesis, guidance throughout data collection and interpretation of results, and feedback on all written work contained in this thesis. Associate Professor Khan provided guidance with data analyses.

Statement of parts of the thesis submitted to qualify for the award of another degree

No works submitted towards another degree have been included in this thesis.

Research involving human or animal subjects

This study was approved by The University of Queensland Behavioural and Social Sciences Ethical Review Committee, Australia (Ref: 2015000860, 1/04/2015; Amendment- 31/07/2015; Amendment- 29/09/2016). A copy of the ethics approval has been provided as Appendix A.

Acknowledgements

Looking back in time, this cliché phrase sounds so accurate ‘how fast does time fly!’ Four years ago (feels like that day) after a 16 hour-ish trip from Dhaka when I arrived at the Brisbane Airport, a security person with a big welcoming smile on face asked me ‘are you looking for a taxi mate?’ That’s the moment I knew it was going to be a treat to live in Brisbane and studying at the University of Queensland. It, indeed, has been a remarkable journey; an experience I would never forget.

I would like to thank the University of Queensland for offering me the opportunity to complete my PhD here. This research project was supported by Australian Federal Governments’ International Post Graduate Research Scholarship, Australian Postgraduate Awards, and Research Training Program Scholarship. I’m incredibly grateful to the beautiful people of Australia, and I acknowledge the Traditional Custodians of the land on which I work and live, and recognise their continuing connection to land, water and community. I pay respect to Elders past, present and emerging.

I would like to thank my advisors: Associate Professor Asaduzzaman Khan and Dr Nicola W Burton. Thank you for giving me the opportunity to work with you, and growing my interest in the field of ‘physical activity and sedentary behaviour’. Asad, my vocabulary isn’t rich enough to thank you – I mean it! I remember you told me ‘PhD is just not an academic degree; it’s more than that. It’s an opportunity, an experience… Try to make the best out of it.’ I have had a great experience being your apprentice. Thank you for mentoring me, encouraging me, and believing in me throughout this journey. I’m going to miss our walk-&-talk meetings from Therapies Annex to the Dutton Parkland via the Green Bridge. Thank you for being a life coach; giving me confidence and a sense of self-worth. Most importantly, thank you for being my local guardian – I feel privileged.

Nicola, what an exceptional mentor you are! There were moments when I was down, kind of lost, and struggled with the bulk of literature. Thank you for inspiring and reassuring me that everyone goes through this, and thank you for help improving my self-esteem. Thank you for being the critique of my write-ups. I remember the day when I practised for a conference with you and Asad, and you told me ‘be realistic and mindful when you are making recommendations. Don’t endorse anything that you don’t believe going to work.’ That changed the way I think now – what an excellent lesson you taught me!

I would like to thank Professor Linda Worrall, Chair of my PhD milestones, and Drs Tracy Kolbe-Alexander and Sjaan Gomersall, independent panel members of my PhD

milestones. I would like to thank Dr David King at the University of Queensland Primary Care Clinical Unit for providing useful comments on sleep health. Especial thanks to Munira, Ngoc, and Gijo for volunteering in a pre-test of my survey. I'm also grateful to all the staff members at the School of Health and Rehabilitation Sciences.

This research would not be possible without those who volunteered their time and completed the surveys. I'm indebted to the participating students and the class lecturers who helped access the students in their classroom. I would like to acknowledge the support of the authorities of the participating institutions for allowing their students to participate in the surveys. I'm thankful to Amim, Rajib, and Rafique, who helped me with data collection, and to Associate Professor Md Ashraful Alam who kindly agreed to preserve raw surveys of the research project at his custody.

To all the PhD students at Seddon North (we call us Seddonites): thank you for your support during the past four years. Like all the past and present Seddonites, I know it's comforting to see other people around you going through the same kind of ups and downs. I'm grateful to have had the opportunity to share my graduate life miseries and moments of joy with you; thank you for excellent workmate ship and friendship.

To some very especial mates at St Lucia – Shohidul, Faisal, Saleha, Zafar, Monir, and Rashed: thank you! Finally, yet importantly, I would like to thank my parents and my sister who supported me throughout the journey and hosted me when I went to Bangladesh for data collection.

So, I'm done? No, I'm not... 'I have promises to keep, and miles to go before I sleep.'

Financial support

This research was supported by an Australian Government Research Training Program Scholarship. This research also received support from the Australian Federal Governments' International Post Graduate Research Scholarship and Australian Postgraduate Awards.

Keywords

active lifestyle, bangladesh, developing country, exercise, health promotion, mental health, physical activity, sedentary behaviour, sleep, wellbeing

Australian and New Zealand Standard Research Classifications (ANZSRC)

ANZSRC code: 111712, Health Promotion, 50%
ANZSRC code: 111706, Epidemiology, 30%
ANZSRC code: 111716, Preventive Medicine, 20%

Fields of Research (FoR) Classification

FoR code: 1117, Public Health and Health Services, 80%
FoR code: 1106, Human Movement and Sports Science, 20%

Table of contents

List of figures

List of tables

List of abbreviations used in the thesis

ß:	regression coefficient
BCE	Before Common Era
BDHS	Bangladesh Demographic and Health Survey
BDT	Bangladeshi Taka
BMI	body mass index
CBT	cognitive behavioural therapy
CI	confidence interval
DALY	disability-adjusted life years
FITT	frequency, intensity, time, type
GEE	generalised estimating equations
GLLAMM	generalised linear and latent mixed models
GPAQ	Global Physical Activity Questionnaire
GSHS	Global School-based Student Health Survey
HBM	Health Belief Model
HPA	hypothalamic-pituitary-adrenal
IPAQ	International Physical Activity Questionnaire
IQR	Inter-quartile ranges
K6	Kessler 6
LMIC	low- and middle-income country
LTPA	leisure-time physical activity
MET	metabolic equivalent task
MPA	moderate-intensity physical activity
MVPA	moderate-to-vigorous intensity physical activity
NCD	non-communicable disease
NGO	Non-government organisation
OR	odds ratio
PA	physical activity
RR	relative risk
SB	sedentary behaviour
SCT	Social Cognitive Theory
SD	standard deviation
SEM	Socio-Ecological Model
SMD	standardised mean difference
STEPS	STEPwise approach to Surveillance
T2DM	type 2 diabetes mellitus
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action

TV	television
UGC	University Grant Commission
UNESCO	The United Nations Educational, Scientific and Cultural Organization
USD	United States Dollar
VPA	vigorous-intensity physical activity
WHO	World Health Organization
YLD	years lost due to disability

Chapter 1: Introduction

1.1 Physical activity, sedentary behaviour and health: a brief overview

Physical activity (PA) is any bodily movement produced by skeletal muscles that requires energy expenditure (World Health Organization n.d.-d). It may occur in different contexts such as at home, work, during transport and/or leisure (Bauman et al. 2012; World Health Organization n.d.-c). PA offers a number of physical health benefits including prevention and management of non-communicable diseases (NCDs) and chronic health conditions such as type 2 diabetes mellitus (T2DM), coronary heart disease and weight gain (Swift et al. 2016). Furthermore, PA has been associated with psychosocial health benefits such as the management and prevention of stress and depression (Swift et al. 2016).

Insufficient PA has deleterious health effects. Globally, insufficient PA is associated with 6-10% of the major NCDs including coronary heart disease, T2DM, and breast and colon cancer (Lee et al. 2012). According to the World Health Organization (WHO), insufficient PA is the 4th leading risk factor for global mortality, accounting for approximately 5.3 million deaths globally per annum (Lee et al. 2012; World Health Organization 2010). Globally, insufficient PA is associated with an estimated $67.5 billion in healthcare expenditures as a consequence of loss of productivity (Ding et al. 2016).

Sedentary behaviour (SB) is defined as any waking behaviour that is characterised by prolonged time spent in a sitting, reclining or lying posture. This may include occupational and non-occupational pursuits such as watching television (TV), using a computer, playing videogames, engaging in other screen-based entertainments (e.g., using social media), and driving or travelling (Tremblay et al. 2017). Prolonged SB has been associated with a number of chronic health conditions, such as T2DM, overweight and obesity, dyslipidaemia, high blood pressure and depressive disorders (Henson et al. 2016; Wilmot et al. 2012). Some research indicates that regardless of the level of PA, prolonged sedentary time remains associated with adverse health outcomes such as T2DM (Henson et al. 2016; Thorp et al. 2011). Hence, SB has been recognised as an emerging public health issue during the past decade (Henson et al. 2016; Wilmot et al. 2012).

Despite the demonstrated benefits of an active lifestyle, a large number of people worldwide have insufficient PA and/or prolonged SB. According to the WHO Global Health

Observatory, around one-quarter of adults aged ≥18 years worldwide did not meet the WHO recommended ≥150 mins/week of moderate intensity or ≥75 mins/week vigorous intensity or an equivalent combination of moderate-to-vigorous PA (MVPA) (Rhodes et al. 2017). Data from 66 countries, including both developed and developing countries, demonstrated that two out of five adults had prolonged SB (defined as ≥4 hrs/day sitting) (Hallal et al. 2012). Research in the United States indicated that adults typically spend more than half (50-70%) of their waking hours in different sedentary pursuits, including sitting for occupational and non-occupational purposes (Matthews et al. 2008).

Though lifestyle and health-related behaviours can form or change at any stage of life, activity behaviours such as PA or SB are typically established during adolescence and young adulthood (Allan 1987; McCracken et al. 2007; Towne et al. 2017), and continue into adult life (Biddle et al. 2010b). Understanding the factors that are associated with PA and SB is the key to effective promotion of an active lifestyle (Bauman et al. 2012). This knowledge is important to inform the development of strategies to overcome barriers and enhance enabling factors at a personal and population level. A range of personal, social and environmental factors may be associated with PA (Bauman et al. 2012; Sallis & Owen 1998; Sallis et al. 2008) and SB (O'Donoghue et al. 2016; Prince et al. 2017).

1.2 Young adults' activity behaviours, and health and wellbeing

Young adulthood, the transition from adolescence to adult life, encompasses ages 18 to 24 years (Jekielek & Brown 2005), and is one of the most important phases of life (Gordon-Larsen et al. 2004). It involves significant life events; young adults may move away from the parental home, commence tertiary education or work, gain more autonomy in life, and may have more freedom in terms of making lifestyle choices (Arnett 2000; Hogan 1978; Jekielek & Brown 2005). During this transition, young adults may adopt health-compromising lifestyle behaviours, such as low levels of PA participation (Berg et al. 2014; Kwan et al. 2012) and prolonged time spent in SB (Lake et al. 2009). These health-compromising behaviours during young adulthood may increase the risk for concurrent physical health issues such as weight gain, and psychological difficulties including anxiety and depression, and lower self-esteem and cognitive performance; as well as chronic health conditions, including osteoporosis, obesity, hyperlipidaemia and diabetes, later in life (Gordon-Larsen et al. 2009; Hallal et al. 2006; Hogan et al. 2013; Tyson et al. 2010). Prolonged sitting in young adults has also been associated with poor physical and psychosocial health (Deliens et al. 2013; Feng et al. 2014; Wu et al. 2015).

The associations between PA and SB with psychological wellbeing may be particularly relevant to young adults, as approximately three-quarters of psychological health-related problems appear by the age of 20 years (World Health Organization n.d.-a). Globally, psychological health problems are the most common causes of disability in young people, contributing to 45% of years lost to disability (YLD) in those aged 10-24 years (Gore et al. 2011). Poor psychological health has a negative impact on psychosocial development and has been associated with substance abuse, poor academic performance and achievements, unemployment and poor quality of life in young adults (Gibb et al. 2010; Patel et al. 2007).

Insufficient PA and prolonged SB among young adults have been associated with poor psychosocial wellbeing including depression, anxiety, psychopathological symptoms and poor sleep (Edwards & Loprinzi 2016; Feng et al. 2014; Kalak et al. 2012; Wu et al. 2016; Wu et al. 2015). PA can reduce psychological problems and may have a role in the management of non-clinical sleep problems of young adults (Al-Eisa et al. 2014; Rangul et al. 2012; Ströhle et al. 2007; Tyson et al. 2010; Wu et al. 2015). Prolonged SB has been reported to be associated with poor sleep quality, depression and other psychopathological problems among young adults (Feng et al. 2014; Wu et al. 2016). There is also evidence from cross-sectional studies that PA and SB can interact and operate synergistically to increase psychological problems among young adults (Feng et al. 2014; Wu et al. 2015).

1.3 Activity behaviours in young adults in low- and middle-income countries

In 2008, more than one-quarter of the global population (1.8 billion) comprised adolescents and young adults aged 10-24 years, and this number has been projected to reach 2 billion by 2032 (United Nations 2009). The majority (90%) of these young people will live in low- and middle-income countries (LMICs) (United Nations 2009). However, young adults in LMICs often get less attention than those in high income countries, or than other age groups in LMICs, in terms of public health investments, and efforts to improve health (Gore et al. 2011). Health-related behaviours of young adults in LMICs have largely been under-studied (Goodburn & Ross 2000; Hallal et al. 2012). Thus, it is important to understand PA and SB in young adults and their associated factors in the context of LMICs.

A recent cross-sectional study with 17,928 undergraduate students from 23 countries, which included 21 LMICs, reported that the prevalence of insufficient PA in

young adults was higher in LMICs than in high-income countries (44% vs. 39%y) (Pengpid et al. 2015). More young adults in LMICs of South-East Asia (51%) and South Asia and China (46%) had insufficient PA than those in LMICs in Near East and Central Asia (32%), and sub-Saharan Africa (37%) (Pengpid et al. 2015). Other studies with Asian young adults have also reported a high prevalence of insufficient PA: 41% to 49% in Malaysia (Mohammed et al. 2014; Sreeramareddy et al. 2012) and 71% in China (Frerichs et al. 2014). Among young adults in South Asia, those in Pakistan were found to have the highest prevalence of insufficient PA (81%) while those in India had the lowest prevalence of insufficient PA (25%) (Pengpid et al. 2015). Another cross-sectional study with 9,427 undergraduate students from 18 countries that included two South Asian countries (Bangladesh and India), found that the prevalence of high SB (top quartile; sitting for >500 mins/day) was slightly higher in Bangladesh (30%) than India (26%) (Peltzer & Pengpid 2014). The high prevalence of insufficient PA and high SB makes young adults in LMICs, in particular South Asia, a priority population group for research on active lifestyles.

The existing literature on patterns and correlates of PA and SB in LMICs is predominantly for adolescents and adults, with little information about the young adult population (Bauman et al. 2012). There is some evidence from undergraduate students in LMICs to suggest that correlates of PA in young adults may differ by gender. One study with young adults found that PA was positively associated with psychosocial health and outcome expectations among males, and with social support and healthy body mass index (BMI) among females (Pengpid et al. 2015). Other factors positively associated with PA of young adults in LMICs include frequent vegetable consumption, being a non-smoker (Seo et al. 2009), seeing others being active, low traffic, safety (low crime rate), and aesthetics (Oyeyemi et al. 2011). A recent cross-sectional study with 9,427 undergraduate students from 18 countries that included 17 LMICs, reported that living off campus, cigarette smoking and insufficient PA were associated with high sitting time in young adults (Peltzer & Pengpid 2014). That study also reported that young adults with depressive symptoms were more likely to have high sitting time (Peltzer & Pengpid 2014).

1.4 Activity behaviours, health and wellbeing among young adults in Bangladesh

Bangladesh, a South Asian country, is ranked as the ninth most populated country in the world, with a population density of 1,217 people per square kilometre (Hong et al. 2017; Kumar & Bano 2017). While recent population dynamics suggest that the country is going through a rapid sociodemographic transition (Islam 2016), it is also experiencing a steady

economic development and has moved from being a low-income country to lower-middle-income country in recent years (World Bank 2015). Over the recent decades, Bangladesh has experienced significant urban transformation and industrialisation (Chandiramani & Airy 2018). This is causing a societal shift, from a predominantly agrarian society towards a labour saving technology-based society (Choudhury 2017), characterised by occupations that require minimal PA and are predominantly sedentary. The sociodemographic changes, urban transformation, industrialisation and modernisation have precipitated lifestyle changes among the Bangladeshi population, such as less time in occupational, recreational- and transport-related PA, and increased use of screen-based technologies (Islam et al. 2017; Rahim et al. 2007).

Studies among Bangladeshi adolescents show a high prevalence of insufficient PA and high recreational screen-time (the most common type of SB among adolescents) (Khan et al. 2017; Khan & Burton 2016). Activity patterns differ by gender, with adolescent girls more likely to be insufficiently active (Khan et al. 2017), and adolescent boys more likely to have high recreational screen-time (Khan & Burton 2016). Cross-sectional studies show that 41% of university students in Bangladesh have insufficient PA (<150 mins/week MVPA) (Pengpid et al. 2015) and a similar proportion (41%) have high sitting time (>6 hrs/day) (Peltzer & Pengpid 2014). However, these studies included participants across a wide age range of 16-30 years. Currently, there are no data on the patterns and correlates of PA and SB for young adults in Bangladesh.

Adolescents and young adults aged 15-24 years form about one-fifth of the total population in Bangladesh (United Nations 2016). NCD related mortality and disability-adjusted life years (DALY) have increased steadily in young adults aged 20-24 years in Bangladesh over the past couple of decades (Global Burden of Disease n.d.). As shown in Figure 1.1, currently, major causes of poor health in this age group are attributable to NCDs and include both physical health problems such as diabetes and cardiovascular disorders; and psychosocial complications such as psychological health and substance use disorders (Global Burden of Disease n.d.).

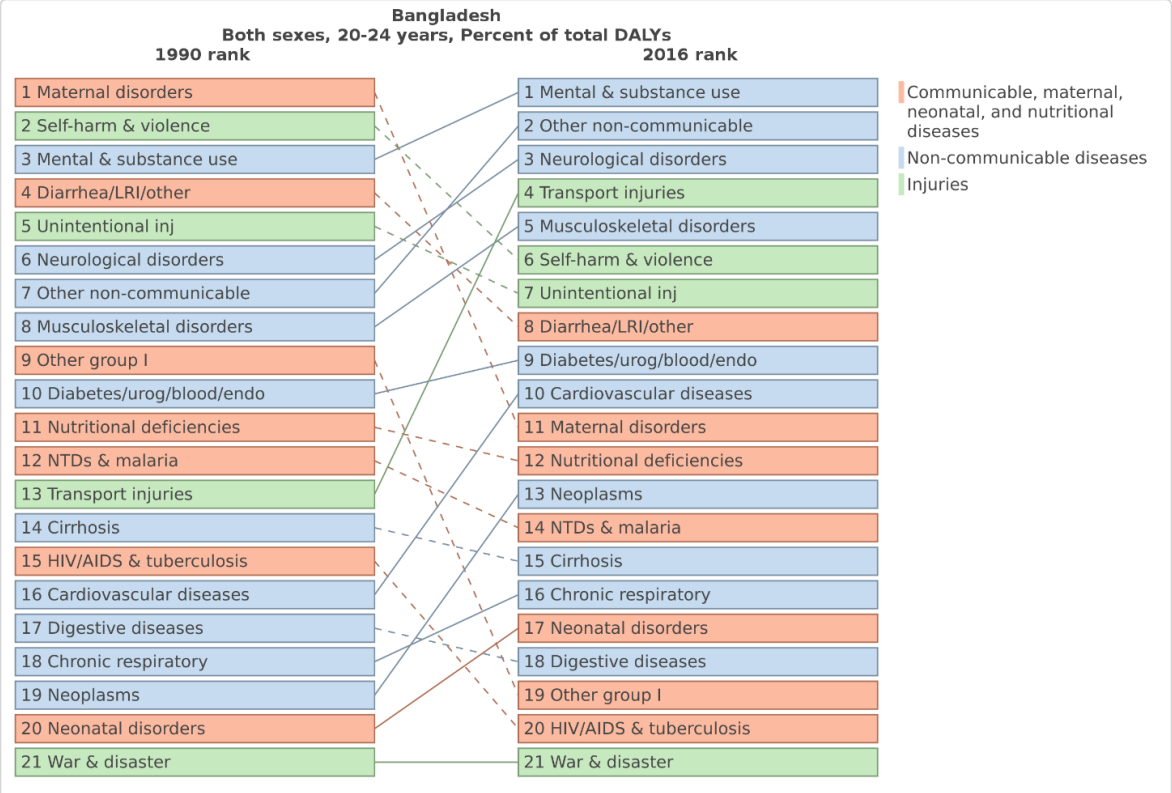

Figure 1. 1: Changes in the major causes of disability-adjusted life years (DALY) among young adults aged 20-24 years in Bangladesh from 1990 to 2016

Adapted from Global Burden of Disease database (Global Burden of Disease n.d.) by Institute for Health Metrics and Evaluation (IHME).
Disability-adjusted life years (DALY) is summary measure, which combines years of life lost due to premature death and years of life lived with disability—i.e., in states of less than full health.
One DALY is equivalent to one lost year of healthy life due to poor health or disease (WHO).

Poor psychological health such as depressive and anxiety disorders are common among young adults aged 20-24 years. According to the 2016 Global Burden of Disease database rankings (Global Burden of Disease n.d.), mental health and substance use disorders are the main causes of poor health among this age group in Bangladesh (Figure 1.2).

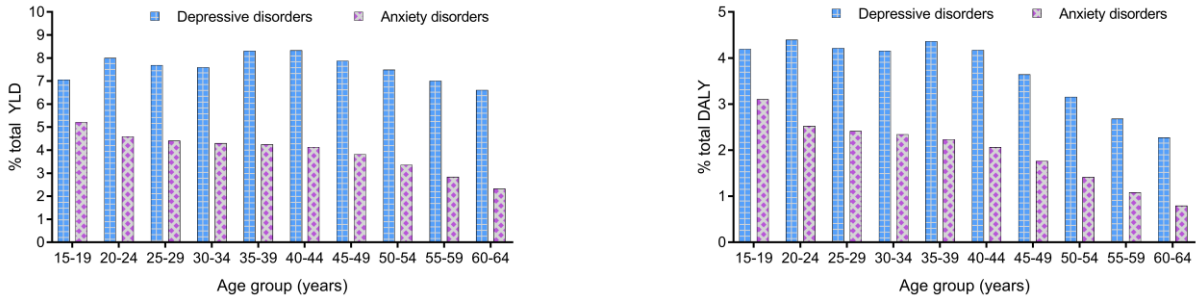

Figure 1. 2: Percent of total YLD* associated with depressive- and anxiety-disorders, by age group in 2016 (*left*) and percent of total DALY associated with depressive- and anxiety-disorders, by age group in Bangladesh in 2016 (*right*)

Constructed based on Global Burden of Disease data (Global Burden of Disease n.d.)
* YLD=Years Lost due to Disability (YLD) for people living with a health condition or its consequences (WHO).

1.5 Rational for the research project

Although active lifestyle has demonstrated positive effect on health and wellbeing of young adults, there is a paucity of data on PA and SB among young adults in Bangladesh. Given the established relationships of insufficient PA and prolonged SB with chronic health conditions and poor psychological wellbeing among young adults (Al-Eisa et al. 2014; Chung & Cheung 2008; Deliens et al. 2013; Edwards & Loprinzi 2016; Feng et al. 2014; Gordon-Larsen et al. 2009; Kalak et al. 2012; Korn et al. 2013; Rangul et al. 2012; Ströhle et al. 2007; Tyson et al. 2010; Wu et al. 2016; Wu et al. 2015), it is crucial to understand the prevalence, patterns and correlates of PA and SB among young adults in Bangladesh. This information can help developing evidence-based strategies to promote active lifestyles (Keating et al. 2005; Lee et al. 2017; Martins et al. 2017).

Given the poor psychological health of the young adults in Bangladesh, enhancing an active lifestyle through promoting PA and reducing SB can be a meaningful and pragmatic strategy to help improve their wellbeing. This can be particularly relevant to resource-poor countries such as Bangladesh, which lack the infrastructure and facilities for mental health (Islam & Biswas 2015).

1.6 Aims of the research program

The overarching aim of this research program was to assess PA and SB, individual level correlates, and associations with psychological wellbeing among young adults aged 18 to 24 years in Bangladesh. The specific objectives of this research project were to:

i) determine the prevalence and sociodemographic patterns of PA and SB;
ii) identify individual-level correlates of PA, SB, and changes in PA and SB over one-year; and
iii) examine the associations of PA and SB with psychological distress and sleep difficulties.

To address these objectives, a one-year prospective study with two assessment points was conducted with university-based young adults in Bangladesh to answer the following research questions:

- 1 (objective 1, section 4.1): What is the prevalence and sociodemographic patterns of PA?
- 2 (objective 1, section 4.2): What is the prevalence and sociodemographic patterns of SB?
- 3 (objective 2, section 5.1): What are the perceived environmental barriers to PA?
- 4 (objective 2, section 5.2): Which individual-level factors are associated with PA?
- 5 (objective 2, section 5.3): Which individual-level factors are associated with SB?
- 6 (objective 2, section 5.4): Which individual-level factors are associated with change in PA and SB over one year?
- 7 (objective 3, section 6.1): Are PA and SB associated with psychological distress?
- 8 (objective 3, section 6.2): Are PA and SB associated with sleep difficulties in this population?

1.7 Overview of thesis

This thesis consists of seven chapters. This introductory chapter provides the context of the thesis by highlighting the gaps in the current evidence base on PA, SB and wellbeing

of young adults in Bangladesh. Chapter 2 provides an overview of the current evidence base on (i) health benefits of PA and risks associated with prolonged SB, with a focus on psychosocial wellbeing among young adults; (ii) PA and SB prevalence and patterns, with a focus on South Asian countries, and (iii) the individual level correlates of PA and SB in young adults, with a focus on research from LMICs.

Chapter 3 describes the methodology for this research program. It details the ethical clearance, study design, participant recruitments and data collection procedures. It also explains the data management, derivation of study measures and data analyses.

Chapters 4 to 6 present the findings of this research program. Chapter 4 uses cross sectional data (Wave 1) and describes the prevalence and sociodemographic patterns of PA and SB (Objective 1; Research question 1 and 2, respectively). Chapter 5 identifies perceived environmental barriers to PA (using Wave 1 data) (Research question 3), individual-level correlates of PA and SB (using prospective data) (Research question 4 and 5, respectively), and factors associated with changes in PA and SB using one-year prospective data (Research question 6) (Objective 2). Chapter 6 describes the associations of PA and SB with psychological distress (Research question 7) and sleep difficulties (Research question 8) (Objective 3).

Chapter 7 is an overall discussion of key findings of the research program. This is done in the context of the current available evidence and considers how the results can inform strategies to promote an active lifestyle among Bangladeshi young adults. It also describes the strengths and limitations of the research. Future research directions are presented.

Chapter 2: Review of the literature

2.1 Introduction

Physical activity (PA) is a health-enhancing behaviour beneficial for physical and psychosocial health. Among young adults, PA participation provides protective effects for a range of chronic health conditions [e.g., type 2 diabetes mellitus (T2DM), cardiovascular diseases], contributes to weight management; and improves self-esteem as well as overall psychological health. Sedentary behaviour (SB), such as prolonged time spent in sitting, can have adverse effects on young adults' health and wellbeing, with an increased risk of weight gain and obesity, T2DM and depression. Although there is good information about PA and SB of young adults in developed countries, little is known about these behaviours in low- and middle-income countries (LMICs), such as Bangladesh, where there is an increasing burden from non-communicable diseases (NCDs) linked to inactive lifestyles. This review provides an overview of PA, SB and associated health outcomes, and the prevalence of these behaviours with particular reference to Bangladesh. This review will also provide a summary of the correlates of PA and SB, and the theoretical models predominantly used to understand these behaviours.

2.2 Physical activity and sedentary behaviour

The World Health Organization (WHO) defines PA as 'any bodily movement produced by skeletal muscles that requires energy expenditure' (World Health Organization n.d.-d). The FITT principles (F=frequency, I=intensity, T=time and T=type) are often used to characterise PA (Rhodes et al. 2017). The first three components of the FITT principles (frequency, intensity and time) reflect the 'dose' of PA, and the fourth (type) can reflect the specific nature of the activity and/or the domain in which typically the activities occur (Rhodes et al. 2017; Schmid & Leitzmann 2014) (Figure 2.1).

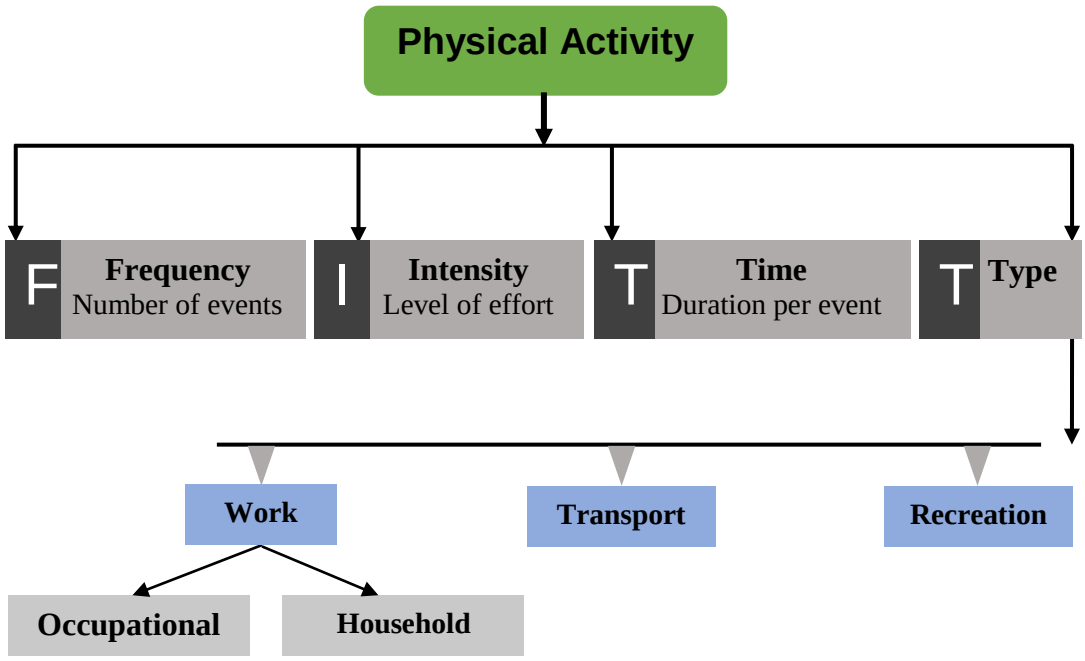

Figure 2. 1: The FITT principles of physical activity

Based on (Rhodes et al. 2017)

Within the FITT principles, frequency refers to *how often* PA is performed by an individual during a reference time period (e.g., per day or week) (Rhodes et al. 2017; Schmid & Leitzmann 2014). The *level of effort* required to perform a specific PA is the intensity, and is related to energy expenditure which is typically expressed as metabolic equivalent tasks (METs) (Rhodes et al. 2017; Schmid & Leitzmann 2014). One MET is the rate of energy expenditure while sitting at rest having an approximate oxygen uptake of 3.5 mL/kg of body weight per minute (U.S. Department of Health and Human Services 1998). Hence, for example, 5 MET denotes an activity requiring 5 times the metabolic rate at rest. Based on the energy expenditure required to perform a specific behaviour, PA can be classified as light-, moderate- or vigorous-intensity (Figure 2.2). The majority of health-related PA research is focused on moderate-to-vigorous PA (MVPA) (Rhodes et al. 2017; Schmid & Leitzmann 2014). Time refers to the *duration* of PA participation (e.g., hours or minutes) (Schmid & Leitzmann 2014). Type of PA can be based whether the activity is aerobic (e.g., walking, swimming) or anaerobic (e.g., high-intensity interval training, weight lifting) in nature, or the domain in which the activity occurs (Rhodes et al. 2017).

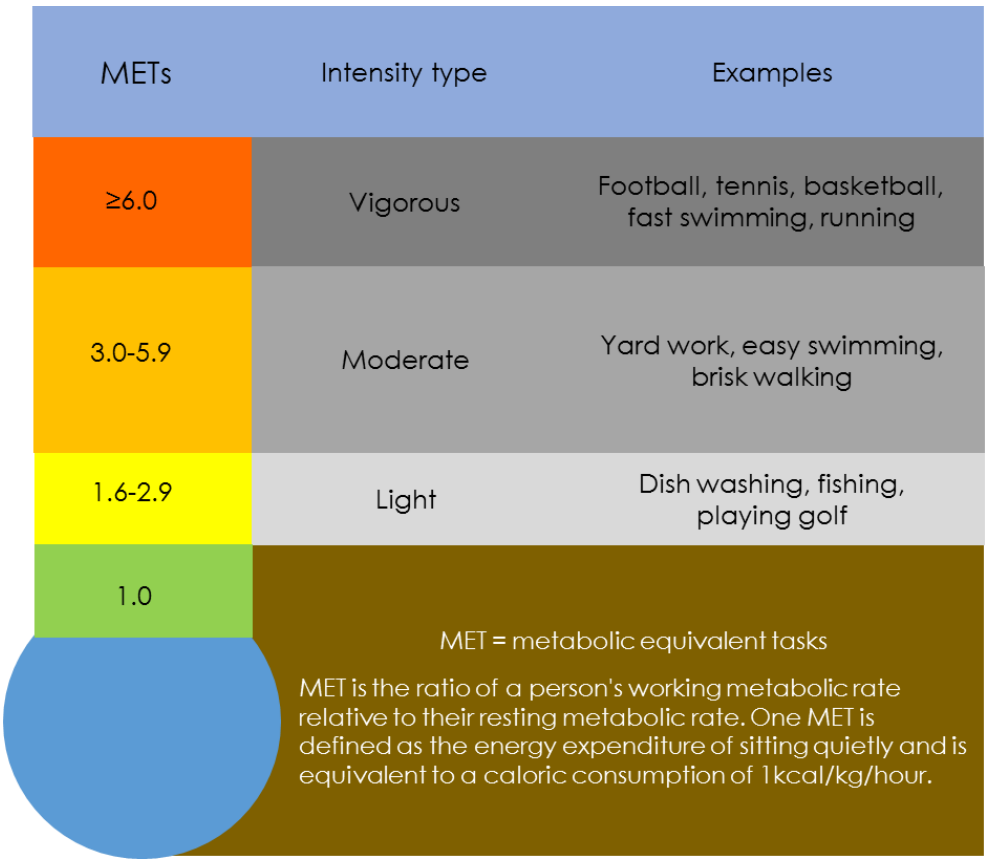

Figure 2. 2: Types of physical activity intensity with examples

Based on (Ainsworth et al. 2011)

PA can be conceptualised in four activity domains; occupation, household (or domestic), transportation (or active transport) and recreation (or leisure) (Figure 2.1) (Hagströmer et al. 2006; Hoehner et al. 2005). Occupational activity refers to employment/work related behaviour such as carrying or lifting loads, carpentry, digging, construction work and packing boxes. Household activity comprises domestic behaviours such cleaning and yard work. Sometimes occupational and household activities are combined into one category of "work". Transportation activity or active transport is undertaken to go to or from a place (e.g. cycling or walking). Recreational activity is done during leisure-time and includes activities like sports, exercise training and running. Some types of PA, such as walking, can occur across domains.

Although sometimes used interchangeably, there are differences between the terms of 'physical activity', 'physical exercise' and 'physical fitness' (Caspersen et al. 1985). Physical exercise shares some common features of PA, for example, both require bodily movement and result in energy expenditure, but they differ as physical exercise is planned, structured, repetitive and purposive, with the primary aim to maintain or improve

physical fitness (Caspersen et al. 1985). Physical exercise, therefore, can be considered as a subset of PA that is done in leisure-time (Caspersen et al. 1985; Thompson et al. 2003). Physical fitness refers to 'a set of attributes that people have or achieve that relates to their ability to perform physical activity' (Caspersen et al. 1985). It includes cardiorespiratory fitness, muscle strength, body composition, and flexibility (Thompson et al. 2003).

Sedentary behaviour (SB) is an independent construct in movement behaviour and the activity continuum, and is defined as any waking behaviour characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture (Tremblay et al. 2017). It may include sitting in different contexts such as watching television (TV) or using other screen-based entertainments, travelling by a car, or using a computer at work (Pate et al. 2008). In contrast, low-intensity PA (such as standing with some gentle ambulation) requires energy expenditure in the range of 1.6 to 2.9 METs. Like PA, SB can occur in different domains: work, domestic, recreation and transport (Owen et al. 2010a).

High sedentariness and being physically active can co-exist (Owen et al. 2012). For example, a person may do regular exercise but also be extremely sedentary throughout waking hours because of prolonged sitting in other contexts, like spending time sitting at a desk at work and watching TV for several hours at home (Biswas et al. 2015). SB has been considered as an independent risk factor of morbidity and mortality (Dunstan et al. 2010; Thorp et al. 2011) and has been recognised as a public health issue in the past decade (Hallal et al. 2012).

2.3 Lifestyle and health

2.3.1 Physical activity and health benefits

According to the Constitution of the WHO (World Health Organization 2005), health is '*a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*'. The concept of health therefore includes, apart from having a disease free life, the ability to achieve activities of daily living, functional capability or functional health status, the ability to participate in a wide range of day-to-day activities with ease and enjoyment, psychosocial wellbeing, and socialization (Blair et al. 1992). PA can have a major role in achieving these health outcomes (Miles 2007).

The history of the concept that ‘being physically active promotes good health’ is established in the remote past. In 2600 BCE, Chinese physicians recognised the necessity of PA for health and wellbeing (Lee et al. 2012). Hippocrates (460 BCE–370 BCE), the ancient Greek physician, emphasised the importance of exercise (and diet) to keep a person healthy (Berryman 2010). The Greek philosopher Plato considered PA, in combination with education, essential for success in life (Ströhle 2009). Galen, a physician of ancient Roman Empire also encouraged moderate exercise for good health (Berryman 2010; Paffenbarger et al. 2001).

PA can provide health benefits for both primary (i.e. preventing incidence), and secondary (i.e. among those at risk) prevention, as well as tertiary management (e.g., through exercise rehabilitation) of some chronic medical conditions and is associated with the reduced risk of premature mortality (Rhodes et al. 2017). Study in Taiwan and the USA reported that engagement in PA for a few minutes per day can offer a longer life expectancy of three (Wen et al. 2011) to 4.5 years (Moore et al. 2012). If the population level of PA participation was increased by 10% from the current level, it could prevent more than half a million (0.53 million) deaths globally each year (Lee et al. 2012). The death toll could be further decreased by more than 1.3 million if PA levels in the global population were increased by 25% (Lee et al. 2012).

PA has been associated with the primary prevention of more than 25 chronic health conditions including cardiovascular diseases, stroke, hypertension and T2DM (Rhodes et al. 2017). As shown in Figure 2.3, PA can reduce the risk of multiple chronic health conditions ranging from 20% relative risk reduction for breast cancer to 40% for T2DM (Rhodes et al. 2017; Warburton et al. 2010). According to a meta-analysis, individuals doing a minimum of 150 mins/week of moderate-intensity recreational PA had a 14% lower risk of coronary heart disease (RR: 0.86; 95% CI: 0.77, 0.96) than those who did no recreational PA (Sattelmair et al. 2011). The meta-analysis also demonstrated that 300 mins/week of recreational PA could reduce the risk of coronary heart disease by 20% [0.80 (0.74, 0.88)] (Sattelmair et al. 2011).

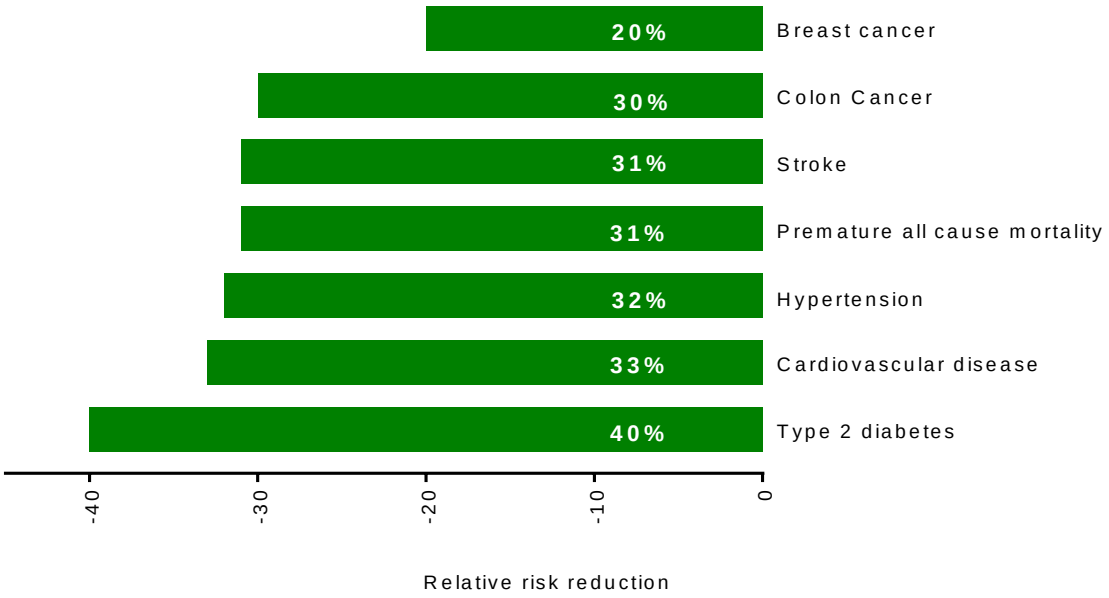

Figure 2. 3: Relative risk reduction of chronic health conditions when active/fit compared with inactive/unfit

Created from (Rhodes et al. 2017)

In addition to physical health, PA is also beneficial for psychosocial health (Rhodes et al. 2017). PA is related to reduced risk of depression, improved cognitive function and higher life satisfaction (Cox et al. 2016; Pedisic et al. 2015; Rebar et al. 2015; Schuch et al. 2018). A meta-meta-analysis of 92 intervention studies found that PA reduced anxiety by a small effect [standardised mean difference (SMD): -0.38 (95% CI: -0.66, -0.11)] and depression by a medium effect [-0.50 (-0.93, -0.06)] in non-clinical populations (Rebar et al. 2015). A more recent meta-analysis of 49 prospective cohort studies reported that individuals with high level of PA had lower odds of incident depression than those who had a low level of PA, regardless of age or geographic location [OR: 0.83 (95% CI: 0.79, 0.88)] (Schuch et al. 2018). A recent systematic review provided preliminary evidence that PA is positively associated with cognitive function (e.g., executive function, memory, and processing speed) in adults aged 18-50 years (Cox et al. 2016). A systematic review of longitudinal studies reported an inverse relationship between PA and Alzheimer's disease and dementia in healthy adults (Reiner et al. 2013).

2.3.2 Sedentary behaviour and health consequences

Prolonged SB can have detrimental health effects. Prolonged sitting has been shown to increase the risk of cardio-metabolic disease and all-cause mortality (Owen et al. 2010b).

A recent meta-analysis reported that high SB was associated with higher risk of all cause-, cardiovascular disease-, and T2DM-mortality, independent of PA (Patterson et al. 2018). The meta-analysis also found TV-time to be associated with cancer mortality (Patterson et al. 2018). Another meta-analysis of prospective studies found that TV-time for >2 hrs/day was associated with a 20% increased risk of T2DM [RR: 1.20 (95% CI: 1.14, 1.27)] and 15% increased risk of cardiovascular disease mortality [1.15 (1.06, 1.23)] (Grøntved & Hu 2011) in high-income countries. Prolonged sitting has also been positively associated with obesity (Thorp et al. 2011), central adiposity, elevated fasting triglyceride level, and different markers of insulin resistance (Owen et al. 2010b), which are linked to an increased risk of cardio-metabolic conditions.

Prolonged SB has also been associated with poor psychological wellbeing (Sanchez-Villegas et al. 2008; Thorp et al. 2011; Zhai et al. 2015). A recent meta-analysis found that individuals with the highest-level of SB had 25% increased risk of depression [RR: 1.25 (95% CI 1.16, 1.35] than those who had low SB (Zhai et al. 2015). High TV-time was found to be associated with 13%, and prolonged computer/internet use with 22%, increased risk of depression (Zhai et al. 2015).

2.3.3 Physical activity, sedentariness and young adults

Participation in PA usually declines during adolescence and young adulthood (Simons et al. 2015). Though variations in PA have been observed across most of the lifespan, late adolescence and young adulthood can have the most significant decrease in PA (Molina-Garcia et al. 2015). Therefore, the transitional period from adolescence to adulthood is a critical phase of life for health behaviours and future risk of developing chronic health conditions. Insufficient PA during early adulthood may increase the risk of developing NCDs such as osteoporosis, obesity, and diabetes in later life (Berg et al. 2014). PA participation can reduce weight gain and increase the likelihood of weight loss and weight maintenance during young adulthood (Gordon-Larsen et al. 2009). Moreover, maintaining PA from adolescence to young adulthood has been observed to significantly reduce cardiovascular disease risk (Rangul et al. 2012).

Young adults engaging in regular PA have been reported to have higher self-esteem, improved external appearance, and are significantly healthier than their insufficiently active counterparts in Israel (Korn et al. 2013). In the UK, it has also been observed that young adults participating in high levels of PA have significantly lower levels

of anxiety and depression (Tyson et al. 2010), and better psychological health and satisfaction with life than insufficiently active young adults in both high-income countries and LMICs (Feng et al. 2014; Rangul et al. 2012; Wu et al. 2016; Wu et al. 2015).

Prolonged SB can result in weight gain and obesity in young adults (Deliens et al. 2013). Weight gain at this stage of life can adversely affect and change blood lipid profiles, fasting insulin and blood pressure, irrespective of race and sex, independent of initial weight (Nanney et al. 2015). Prolonged SB, such as screen-time, has been positively associated with depression, anxiety, sleep difficulties and other psychopathological problems in young adults (Feng et al. 2014; Wu et al. 2016; Wu et al. 2015).

There is also evidence that insufficient PA and high SB in young adults can interact and increase the odds of poor psychological wellbeing (Feng et al. 2014; Wu et al. 2015). A recent cross-sectional study reported that participants who had low PA (<3 days/week of exercise) and high SB (>2 hours/day screen-time) were more likely to have depression, anxiety, and other psychopathological symptoms than those with high PA and low SB (Wu et al. 2015). According to another cross-sectional study, young adults with high PA (≥30 minutes/day of sports or vigorous free play for ≥3 days/week) and low SB (≤2 hrs/day) were 50% less likely to report poor sleep than those who had low PA and high SB (Feng et al. 2014).

2.4 Physical activity recommendations

PA recommendations are a crucial component for the effective promotion of an active lifestyle at the population level (Kahlmeier et al. 2015). Numerous recommendations and guidelines on PA are available, these include for example: the WHO guidelines (World Health Organization 2010); national or country level guidelines (e.g., Australia's Physical Activity and Sedentary Behaviour Guidelines, Physical Activity Guidelines for Americans, Canadian Physical Activity Guidelines) (Tremblay et al. 2011) and disease-specific guidelines (e.g., National Heart Foundation of Australia recommendations on PA for individuals with cardiovascular diseases (Briffa et al. 2006)).

The WHO developed recommendations on PA (World Health Organization 2010) with an overall aim to provide national and regional level policy makers with guidelines on different aspects of PA; duration, intensity, type and total duration required for the prevention of NCDs. It was expected that the recommendations would be translated into

actions; i.e., country level PA promotion goal setup, promotion of PA, resource allocation for an active lifestyle and facilitation of national PA surveillance program (World Health Organization 2010).

According to the WHO, adults aged 18-64 years should:

i) participate in at least 150 minutes of moderate-intensity aerobic PA throughout the week, or do at least 75 minutes of vigorous-intensity aerobic PA, or an equivalent combination (resulting in at least 600 MET-mins/week energy expenditure) of MVPA in bouts of at least 10 minutes duration;
ii) perform aerobic activities in bouts of at least 10 minutes duration;
iii) increase their moderate-intensity aerobic PA to 300 mins/week, or engage in 150 minutes of vigorous-intensity aerobic PA per week, or an equivalent combination of MVPA for additional health benefits; and,
iv) do muscle-strengthening activities involving major muscle groups on two or more days a week.

These WHO guidelines are widely used in LMICs, including Bangladesh, most of which are lacking country level PA guidelines. In Bangladesh, the WHO guidelines are used as a means of surveillance of NCD risk factors.

2.5 Prevalence of insufficient physical activity and sedentary behaviour

For population-level surveillance purposes, the prevalence of insufficient PA corresponds to non-adherence to the WHO MVPA recommendations. The criteria used to define insufficient PA in the context of surveillance is however, to some extent, different from the activity recommendations outlined in sub-section 2.4. For example, the WHO PA recommendations include both aerobic (i, ii and iii) and muscle-strengthening components (iv). For surveillance purposes, however, typically only component ‘i’ and ‘ii’ are used; i.e., adults aged 18-64 years not accumulating at least 150 mins/week of MVPA are considered to have insufficient PA. Physical inactivity and insufficient PA are often used interchangeably in this context.

Compared to PA, SB is a relatively new area of research; thus, globally comparable data is sparse. Recently Hallal and colleagues assessed and reported the prevalence of SB from the WHO’s STEPwise approach to surveillance (STEPS) surveys and the Eurobarometer data from 66 countries (Hallal et al. 2012). In parallel with the study by

Hallal and colleagues, the following text will use the definition of high SB as ≥240 mins/day (4 hrs/day) in sitting to discuss global prevalence.

2.5.1 Global prevalence of insufficient physical activity and sedentary behaviour

A large number of people worldwide have insufficient PA. Based of self-report measures such as the Global Physical Activity Questionnaire (GPAQ) and the International Physical Activity Questionnaire (IPAQ), ~90% of countries worldwide had population-level prevalence data from at least one survey (Hallal et al. 2012). However, until 2010, a global estimate of the prevalence of insufficient PA was difficult because of non-harmonised nature of these data. The WHO accumulated and harmonised available data from different countries and included this in the Global Health Observatory (Hallal et al. 2012; Rhodes et al. 2017). These data were standardised with statistical adjustments for differences in the year of survey, questionnaires that assessed PA and the definition of insufficient PA (Hallal et al. 2012; Rhodes et al. 2017).

According to the Global Health Observatory, in 2010, one in four adults aged >18 years globally had insufficient PA (Rhodes et al. 2017). A higher proportion of females (27%) were insufficiently active than males (20%) (Rhodes et al. 2017). The Observatory data also suggested that there were differences in the prevalence of adults' insufficient PA based on geographic location and country income classification (Rhodes et al. 2017). For example, within the WHO regions, South-East Asia had the lowest prevalence of insufficient PA (15%), and the Americas (32%) and Eastern Mediterranean regions (31%) had the highest prevalence in adults aged >18 years in 2010. As shown in Figure 2.4, the highest prevalence of insufficient PA was in high-income countries with one-third of the adults not meeting the PA recommendations. In low-income and lower-middle-income countries, the prevalence of insufficient PA was comparatively lower at 17% (Rhodes et al. 2017).

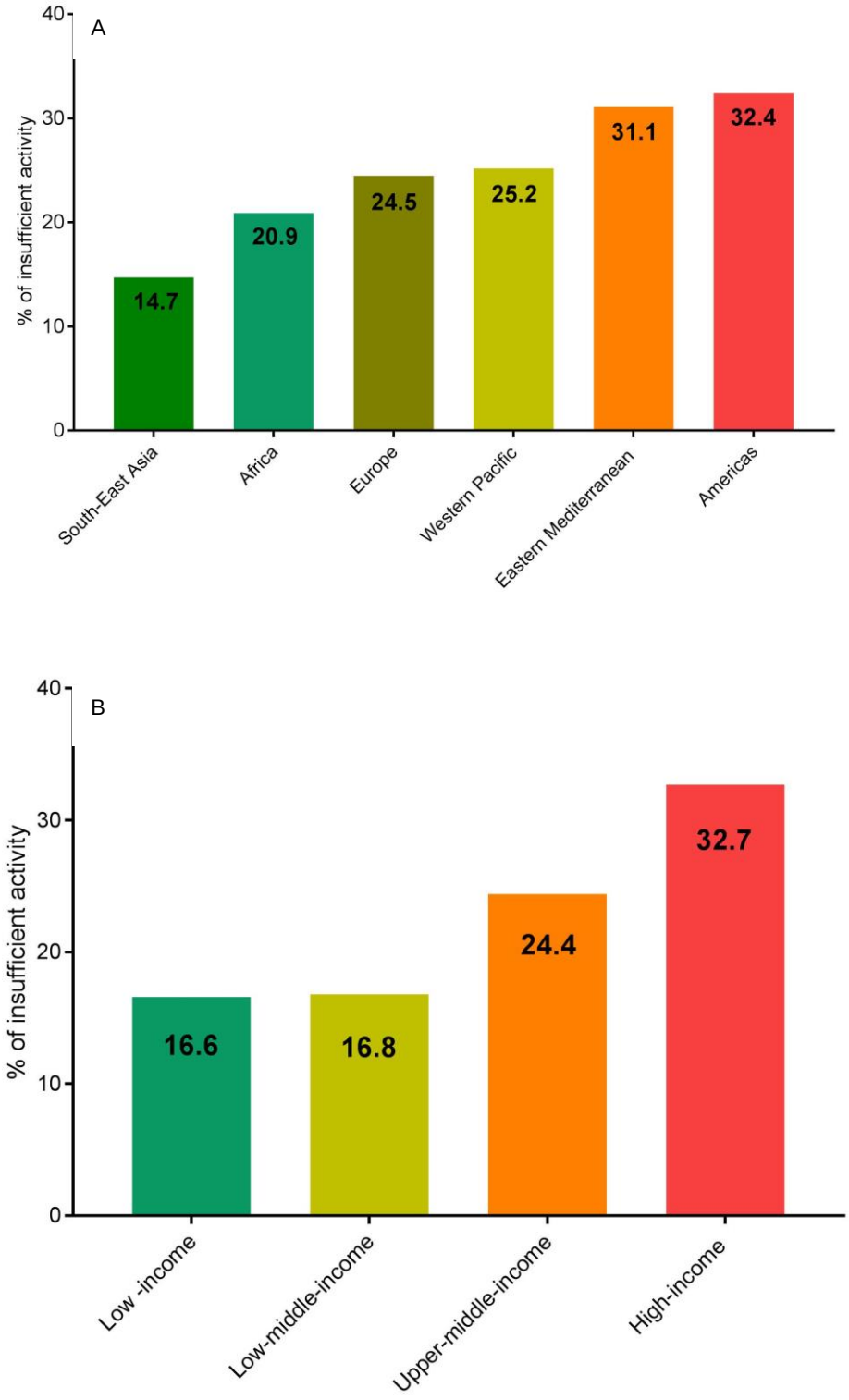

Figure 2. 4: Prevalence of insufficient physical activity among adults aged >18 years in 2010, by World Health Organization regions (*A*) and World Bank income categories (*B*)

Constructed based on data from (Rhodes et al. 2017)

Available data from the STEPS surveys and the Eurobarometer studies suggest that approximately 42% of adults aged ≥15 years spent ≥240 mins/day (4 hrs/day) in sitting (Hallal et al. 2012). According to STEPS and Eurobarometer data, more people in the WHO European region (64%) and in the Americas (55%) had high sitting time with South-East Asian countries having the lowest prevalence (24%) (Figure 2.5).

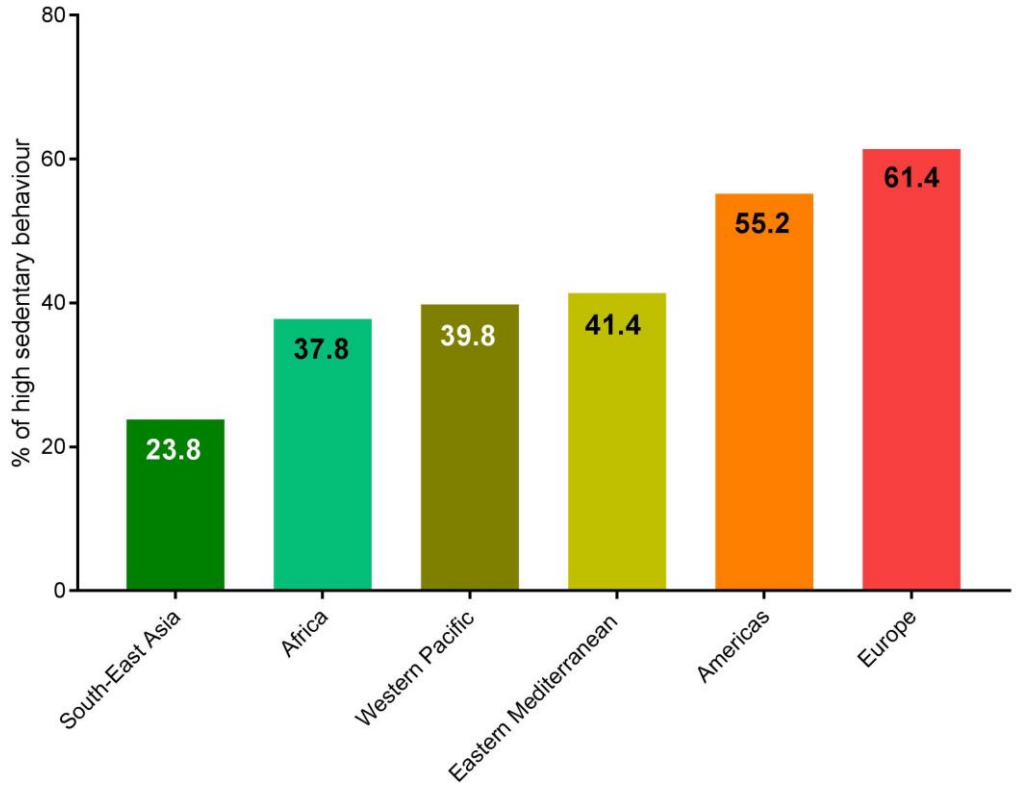

Figure 2. 5: Prevalence of prolonged sedentary behaviour (sitting for ≥4 hours/day) among adults aged ≥15 years, by World Health Organization regions

Constructed based on data from (Hallal, et al., 2012)

2.5.2 Insufficient physical activity and prolonged sedentary behaviour in South Asia

South Asia is the most densely populated region in the world (Desai 2002). It is comprised of eight countries – Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka (Figure 2.6). The region hosts approximately one-fourth (25%) of world's population (Siegel et al. 2014) in a land area of only about 2.4% of world's land mass (Desai 2002).

The WHO's STEPS surveys provided data on PA prevalence in these countries for participants aged 15-74 years. Table 2.1 summarises PA data from the 15 STEPS surveys

that were conducted during 2002 to 2013 in South Asian countries (Ranasinghe et al. 2013).

Figure 2. 6: Map of South Asia

Table 2. 1: A summary of prevalence of insufficient physical activity in South Asian countries as reported in the STEPS surveys (Ranasinghe et al. 2013)

Country	Number of surveys conducted	Year of surveys	Sample characteristics	General method used		Prevalence of insufficient activity
				Activity intensity	Activity domain	
Bangladesh	2	2002	National* (total: 11,409); 50.7% female; both urban and rural (63.8% urban); age: 25-64 years	V, M, L	HW, W, T	52%
		2010	National (total: 9,275); 53.5% female; both urban and rural (50% urban); age: ≥25	V, M	W, R, T	27%
Bhutan	2	2004	Subnational (total: 410); hospital outpatient based; age: ≥ 35 years; details not provided	L	W, R, T	14%
		2007	Subnational (total: 2,484); 54.2% female; only urban; age: 25-74 years	V, M, L	W, R, T	59%
India	2	2004	Subnational (total: 44,491); 6 centres based in 6 states; 50.8% female); apart from urban (34.2%) and rural (30.4%) cohort another cohort 'slum' was used, which comprised of 35.4% of study population; age: 15-64 years	V, M	W, R, T	16%
		2007	Subnational (total: 38,064); in 7 states; 55.6% female; both urban and rural (48.8% urban); age:15-64 years	V, M, L	NA	42-81%**
Maldives	2	2004	Subnational (total: 2,026); 54.0% female; only urban; age: 25-64 years	V, M, L	W	93%***
		2011	Subnational (total: 1780); 62.7% female; urban only; age: 15-64 years	V, M, L	W, R, T	46%

Country	Number of surveys conducted	Year of surveys	Sample characteristics	General method used		Prevalence of insufficient activity
				Activity intensity	Activity domain	
Nepal	4	2003	Subnational (total: 2,030); 50.2% female; urban only; age: 25-64 years	V, M	W, R, T	82%
		2004-5	Subnational (total: 7,792); 52.8% female; both urban and rural; age: 15-64 years	NA	W, R, T	52% (work domain), 19% (transportation) 86% (leisure time)
		2007-8	National (total: 4,328); 55.9% female; both urban and rural (50.2% urban); age: 15-64 years	V, M, L	W, R, T	6%
		2012-13	National (total: 4,143); 67.8% female; both urban and rural; age: 15-69 years	V, M, L	W, R, T	4%
Pakistan	1	2005	Subnational	NA	NA	11-92%†
Sri Lanka	2	2003	Subnational (total: 3,000); female (50%); Western province only; age: 15-74 years	V, M, L	W, R	16%
		2006	National (total: 11,680), 50.6% female; age:15-64 years	V, M, L	W, R, T	25%

*According to the WHO STEPS website sample was nationally representative; however, data were collected from Dhaka district only.
**An account of physical activity/inactivity level was not reported over the entire study population; only state-wise data were provided.
***The candidate calculated from the available data.
†81.5% urban and 66.5% rural population were reported to be inactive in work related physical activity, whereas in transport domain inactivity was reported to be 10.7% and 11.9% people in urban and rural area. Total 91.6% urban and 91.4% rural people were reported to be inactive in leisure time physical activity domain.
Abbreviations: V=vigorous intensity physical activity; M=moderate intensity physical activity; L=Low intensity physical activity; W=physical activity in work domain; R=physical activity in recreational or leisure time domain; T=physical activity in transportation domain; HW=physical activity reported in household works only; NR=not reported.

In South Asia, SB has been reported in the STEPS surveys conducted in Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka. Table 2.2 lists the prevalence of SB in South Asian countries as reported in the STEPS surveys (Ranasinghe et al. 2013).

Table 2. 2: Time spent in sedentary behaviour in South Asian countries as per the STEPS report (Ranasinghe et al. 2013)

Country	Year	Sample characteristics	Sedentary behaviour
Bangladesh	2010	National (total: 9,275); 53.5% female; both urban and rural (50% urban); age: ≥25	Median of 120 mins/day (men: 120 mins/day, women: 150 mins/day)
Bhutan	2007	Subnational (total: 2,484); 54.2% female; only urban; age: 25-74 years	Half of the participants (50%) had ≥240 mins/day sedentary time
India	2004	Subnational (total: 44,491); 6 centres based in 6 states; 50.8% female); apart from urban (34.2%) and rural (30.4%) cohort another cohort 'slum' was used, which comprised of 35.4% of study population; age: 15-64 years	Average time reported. Men (277.88 mins/week), women (297.71 mins/week)
Maldives	2011	Subnational (total: 1,780); 62.7% female; urban only; age: 15-64 years	Men (300 mins/day), women (270 mins/day)
Nepal	2007-8	National (total: 4,328); 55.9% female; both urban and rural (50.2% urban); age: 15-64 years	Average 561.2 mins/day
	2012-13	National (total: 4,143); 67.8% female; both urban and rural; age: 15-69 years	Average 152.7 mins/day
Sri Lanka	2003	Subnational (total: 3,000); female (50%); Western province only; age: 15-74 years	Average reported. Men (223.8 mins/week), women (229.2 mins/week)
	2006	National (total: 11,680), 50.6% female; age:15-64 years	120 mins/day

2.5.3 Insufficient physical activity and sedentary behaviour in Bangladesh

Bangladesh is the eighth most populated country in the world with a population of 153 million (Chowdhury et al. 2013). NCDs currently account for an estimated 61% of total deaths in Bangladesh (Biswas et al. 2017). Over the last 33 years, rates of overweight and obesity have more than doubled among adults in Bangladesh, increasing from 7% in 1980 to 17% in 2013 (icddrb 2014). The prevalence of cardiovascular disease (Abegunde et al. 2007) and diabetes (Abegunde et al. 2007; International Diabetes Federation 2013) is increasing at an alarming rate in the country. According to the Global Burden of Disease database (Global Burden of Disease n.d.), NCD-related poor health among young adults has increased considerably over the past decades in Bangladesh. Within the South Asian countries, NCD-related morbidity is the highest among young adults aged 20-24 years in Bangladesh compared to other countries (Figure 2.7).

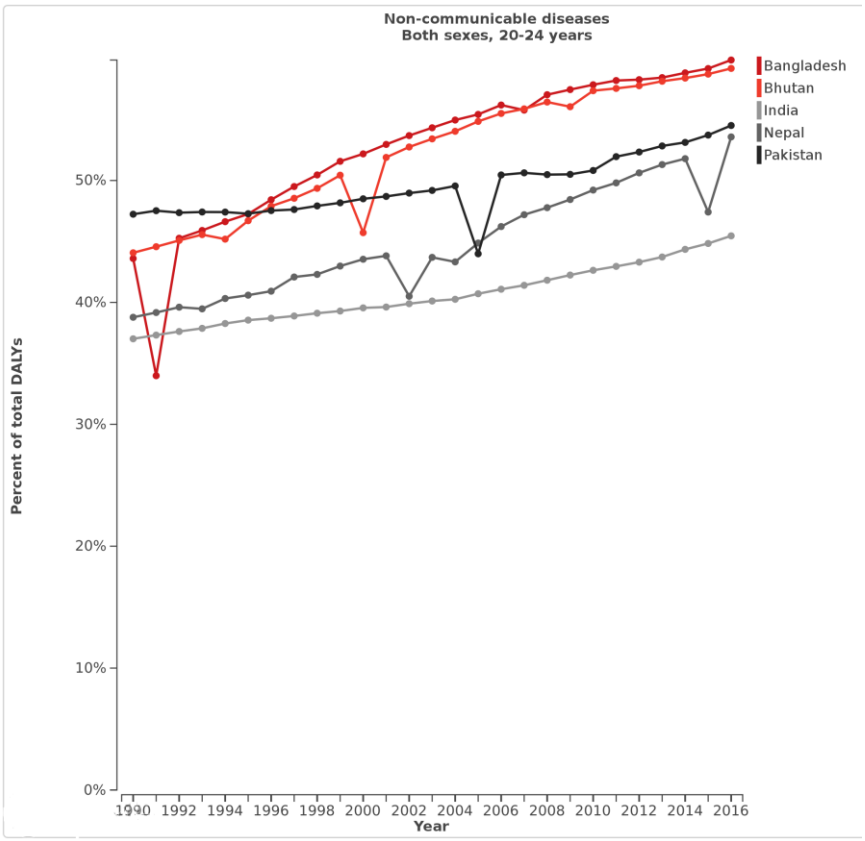

Figure 2. 7: Increasing trend of non-communicable disease-related DALYs in young adults (20 to 24 years) in South Asian countries, from 1990 to 2016

From the Global Burden of Disease database (Global Burden of Disease n.d.), Institute for Health Metrics and Evaluation (IHME)

Like many other South Asian countries, most of the research relating to PA has been conducted under the STEPS surveillance program. The first STEPS survey in Bangladesh was conducted in 2002 using a subnational sample of 11,409 adults aged 25-64 years from urban and rural areas of Dhaka, the capital of the country, and found that 52% of the participants were insufficiently active (Rahman et al. 2004). The second STEPS survey in Bangladesh was conducted with a nationally representative urban and rural sample of 9,275 adults aged ≥25 years in 2010, and found that 27% people were insufficiently active (World Health Organization 2011).

From these STEPS reports, it may appear that prevalence of insufficient PA has decreased over the past eight years in Bangladesh. However, the methodological aspects should be considered carefully. Both STEPS surveys followed the same survey protocol as suggested by the WHO, used the same survey instrument and definition of insufficient PA, and the ratio of male to female participation was comparable (49% vs 46% male respectively in 2002 and 2010). However, the first STEPS survey used a sub-national sample composed of 36% rural participants, whereas the second survey was conducted across the country using an equally distributed rural-urban sample. Furthermore, the rural participants in the first STEPS survey were from Dhamrai, a semi-urban area. Rural people can be more physically active than urban people due to several factors such as involvement in physically demanding work (e.g., agriculture-based manual work) and having less access to mechanised transport (Anjana et al. 2014). Thus, the first survey was dominated by urban and semi-urban people, which is likely to provide an overestimate of country's insufficient PA level.

Apart from the STEPS surveys, there is another report on PA levels in Bangladesh (Guthold et al. 2008), which was a part of the WHO's World Health Survey conducted during 2002/04. That survey, unlike the STEPS surveys, used the IPAQ as the survey instrument. Participants in that survey were aged 18–69 years, and so included young adults aged 18-24 years. According to that survey, 17% of Bangladeshi adults had insufficient PA with more women (27%) having insufficient PA than men (7%) (Guthold et al. 2008). Though young adults were included in that survey, no country age specific prevalence of insufficient PA was reported. A recent cross-sectional study conducted among 395 urban and 397 rural adults in Bangladesh (Moniruzzaman 2014) reported that approximately 45% of study participants (50% in urban and 40% in rural areas) had insufficient PA. However, the second STEPS survey reported a much lower rate (27%) of insufficient PA, though both studies used the GPAQ as the survey instrument and were

conducted at the same period across urban and rural areas. According to a recent multi-country cross-sectional study (Pengpid et al. 2015), 32% male and 59% female students aged 16 to 30 years in Bangladesh were insufficiently active. That study used the IPAQ as the instrument and defined insufficient PA doing <600 MET-mins/week of activity. While the GPAQ captures domain specific PA (i.e., work, transport and leisure-time) to obtain overall PA for a typical week (Bull et al. 2009), the IPAQ asks about overall time spent doing different intensities of PA with a recall period of the last seven days (de Courten 2002).

To date, the available data on PA in Bangladesh, mainly from STEPS initiatives, have been generated from participants aged ≥25 years. Though the World Health Survey included participants of 18-69 years, it did not report age specific PA prevalence; rather they presented an overall country estimate for PA. The unavailability of PA data for young adults in Bangladesh is alarming, especially when PA has demonstrated protective role in the control of NCDs, which are on the rise in Bangladesh.

The first STEPS survey did not report time spent in sitting in Bangladesh. According to the second STEPS report, adult women in Bangladesh spent more time in sitting (median of 150 mins/day) than adult men (median of 120 mins/day). As the STEPS survey results are limited to those aged ≥25 years in Bangladesh, there is no information on young adults' SB for the country.

Given the strengths of prospective data over cross-sectional data (Cashmore & Parkinson 2014), a prospective study on young adults is likely to generate valuable information on PA and SB and changes over time. The obtained information can help formulating strategies to promote an active lifestyle among young adults in Bangladesh.

2.6 Theories and models of health behaviour

To achieve positive changes in health behaviour, like PA, there is a need to understand 'why people behave as they do and what might motivate them to change' (Glanz & Maddock 2002). To answer this question, different theories and models of health behaviours have been developed (Glanz & Maddock 2002). A theory is defined as 'a systematic explanation for the observations that relate to a particular aspect of life' that is organized around different ideas, concepts and constructs (Babbie 2015). A model is

considered as a ‘subclass of theory’ that represents and acts as a vehicle for the application of the theory (Brown 2010).

PA and SB are complex behaviours that may be influenced by the interaction between a number of personal, interpersonal, socio-cultural and environmental factors (Assah et al. 2015; Owen et al. 2011; Pengpid et al. 2015). A model based approach can be helpful for understanding behaviour in a specified setting with a particular population (e.g., young adults at university) to enrich, inform, and complement the useful knowledge to promote health (Glanz et al. 2008; Smith & Biddle 2008). Social Cognitive Theory and the Social-Ecological Theory are widely used to assess the potential factors associated with PA.

Social Learning Theory, later renamed as Social Cognitive Theory (SCT) suggests that behaviour is affected by several factors (Bandura 1986). These may include environmental stimuli, personal features and characteristics of the behaviour itself (Bandura 1986; Rosenstock et al. 1988).

The relationship between individuals and the environment is a key component of the SCT (Baranowski et al. 2002). The environment includes both the social environment of family, friends, peers and members of the community; and the physical environment of physically external objective factors to the person. According to the SCT, the likelihood of behaviour is determined by several factors (Bandura 1986). These include the person’s subjective perception of the environment (situation); knowledge and skill to perform the behaviour (behavioural capability); outcomes expected from the behaviour (expectations); and the value placed on the anticipated outcomes (expectancies). Other factors include personal regulation of behaviour (self-control), opportunities to observe actions and outcomes of others’ behaviour (observational learning), and responses that increase the possibility of reoccurrence (reinforcements) of a behaviour. Self-assurance to perform the behaviour as well as overcoming the barriers (self-efficacy) and approaches to manage emotional stimuli (emotional coping responses) also influence behaviour (Baranowski et al. 2002).

The SCT is one of the most successful theories in exercise behaviour (Biddle & Nigg 2000) and has been extensively used in PA research (Bagherniya et al. 2015; Joseph et al. 2015). It has, however, been criticised as very comprehensive in its formulation (Baranowski et al. 2002) and ambitious (McAlister et al. 2008), due to the fact that virtually

almost any human phenomena or event can be explained using one or more concepts of the theory. The SCT overemphasises intrapersonal influences, and overlooks relational and cultural influences (Wingood & Di Clemente 2002).

Most theories and models emphasise individual behaviour with little consideration to socio-cultural and physical environments (McLeroy et al. 1988). Health behaviours are shaped by not only individual-level factors, but also the socio-cultural and the environmental factors surrounding an individual. Health behaviours are believed to improve if an individual's surroundings offers healthy choices, which may motivate an individual to make these supportive and enjoyable choices (World Health Organization 1986).

The Social-Ecological Model (SEM) emphasises the influence of the social aspects, which includes institutional as well as cultural factors, on behaviour (Buchan et al. 2012). According to the SEM, behaviour is influenced by interpersonal, intrapersonal, sociocultural, policy and physical environmental factors and it is plausible that these factors interact with each other.

A major criticism of the SEM is that it has been used in largely unidirectional ways (Patrick et al. 2013). It has also been criticised for requiring extensive details on ecological aspects (Saad 2014). However, this model combines variables from other recognised and widely accepted health behaviour models, such as the health believe model (HBM), the theory of reasoned action (TRA) and the theory of planned behaviour (TPB), and the SCT. The SEM considers different aspects of the social (such factors like supportiveness of a social setting) and physical environment (both natural and built environment); cultural factors associated with behaviour; and public policy that may differ from country to country, from society to society, across different cultural settings and even across different geographical locations (Bauman et al. 2012). This model is a useful method to study PA correlates as the model can integrate a wide range of variables associated with PA (Burton 2006; Sallis et al. 2008).

2.7 Correlates of young adults' physical activity and sedentary behaviour

2.7.1 Physical activity correlates

PA correlates research has identified a number of individual-level factors associated with PA among young adults. This research has primarily been conducted in developed countries, with a few studies in LMICs. Research with young adults, primarily university students, has demonstrated that being female was associated with lower physical activity among young adults in high-income countries such as Israel (Shuval et al. 2009) and the USA (Buckworth & Nigg 2004). Low fruit consumption, cigarette smoking, and perceptions of being overweight were associated with insufficient PA among young adults in high-income countries such as the USA and South Korea, and LMICs such as India and Costa Rica (Awadalla et al. 2014; Seo et al. 2009). Perceived benefits of PA, past positive attitude towards PA, and higher PA efficacy were reported to be positively associated with PA in Japanese undergraduate students (Yasunaga et al. 2014). Higher PA efficacy was also associated with higher PA of Israeli and US university-based young adults (Rovniak et al. 2002; Shuval et al. 2009). Parental PA habits was positively associated with PA of a nationally representative sample of Spanish university students (Romaguera et al. 2011)., US university students (age 19.6±2.73 years) reported PA enjoyment (McArthur & Raedeke 2009) and Saudi university students (age 20.1±1.4 years) reported membership in a sport club (Awadalla et al. 2014) to be positively associated with PA. Socio-cultural factors such as having an active friend and seeing others being active were associated with higher PA of urban university students in LMICs such as China (Yuan et al. 2013) and Nigeria (Oyeyemi et al. 2011). Social support for PA from family and friends was reported as a positive correlate of PA in high-income countries such as Spain, Japan, and Belgium (Deliens et al. 2015; Rovniak et al. 2002; Yasunaga et al. 2014). Saudi female university students aged 20.4±1.5 years who were living in a villa or large house were more active than their counterparts who were living in a flat (Khalaf et al. 2013). Potential environmental correlates of university students' PA included less traffic; low crime rate; better neighbourhood aesthetics in Nigeria (Oyeyemi et al. 2011); favourable climate in Saudi Arabia (Musaiger et al. 2014); having access to open space in Japan (Yasunaga et al. 2014); affordability, availability and accessibility to PA equipment and facilities; and living on campus in Belgium (Deliens et al. 2015).

2.7.2 Sedentary behaviour correlates

There are limited data on correlates of SB in young adults. A recent systematic review of correlates of different types of SB (e.g., TV-time, video gaming) identified 256 studies, of which 19 (7%) were with young adults, mostly from developed countries such as Australia and the USA (70%) (Prince et al. 2017). Factors such as low socioeconomic status, having a sedentary friend, a lack of intentions to reduce SB, negative attitudes about PA, stress, and depression have been reported as correlates of SB [see supplementary Table S2 - Prince and colleagues for details (Prince et al. 2017)]. Younger age, living off campus (alone or with family members), having depression, and insufficient PA were associated with higher sitting time among university students aged 16-30 years in an 18-country study that included 17 LMICs (Peltzer & Pengpid 2014). Low education level of parents and having a TV/computer in the bedroom have been associated with high sedentary screen-time of young adults in LMICs such as Turkish university students aged 20.8±1.61 years (Caglar et al. 2017). Positive correlates of young adults' SB include high body mass index (for males), having depression, stress, low socio-economic status (for females) (Clarke et al. 2009; van den Berg et al. 2007). Being underweight, overweight or obese have also been reported to be associated with high internet use among Thai university students aged 18-25 years (Peltzer et al. 2014). According to a recent qualitative study in Belgium, enjoyment for watching TV, past sedentary habits, lack of PA, high academic pressure, availability and access to TV/computer, and ease of access to internet were associated with university students' SB (Deliens et al. 2015).

2.7.3 Physical activity and sedentary behaviour correlates in Bangladeshi young adults

PA and SB correlates have been predominantly studied in developed countries such as Australia, Japan, the UK, and the USA. Correlates studies in LMICs are scarce. Correlates identified among young adults in developed countries may not necessarily be the correlates of young adults in LMICs like Bangladesh, who have a different sociodemographic profile, are from a distinct cultural and economic background and therefore may have a different lifestyle profile. So far, no studies have looked at correlates of PA and SB in the Bangladeshi young adults.

2.8. Summary

There is strong evidence in support of health benefits of PA and adverse health consequences of high SB. Insufficient PA and prolonged SB are linked to increased risk of NCDs and poor psychosocial wellbeing, which have an increasing prevalence in Bangladeshi young adults. Though some PA and SB data for Bangladesh are available for adolescents aged 13-17 years and adults aged ≥25 years, no studies has examined these behaviours in relation to young adults (18-24 years). It is also important to understand the factors that may influence young adults' PA and SB in Bangladesh, to inform the development of promotion strategies. There is, therefore, an urgent need for research on the prevalence, patterns and correlates of PA and SB of young adults in Bangladesh. Understanding how PA and SB are associated with psychological wellbeing of young adults in Bangladesh may also help understand high rates of poor wellbeing in the country, as well as inform health promotion.

To assess the prevalence and sociodemographic patterns of PA and SB, individual-level correlates of PA, SB and changes in PA and SB, and to examine associations of PA and SB with psychological wellbeing among young adults aged in Bangladesh, a prospective one-year study with two-assessment points was conducted. The next chapter (Chapter 3) describes the methodological aspects of the research program.

Chapter 3: Methods

3.1 Introduction

As stated in Chapter 1, the overarching aim of this research project is to assess the prevalence and sociodemographic patterns of physical activity (PA) and sedentary behaviour (SB), identify the correlates of PA, SB, and changes in PA and SB, and examine their associations with psychological wellbeing among young adults aged 18 to 24 years in Bangladesh. A person, however, can be a university student at any age and therefore all university students may not be young adults. Hence, the participants of the research program were young adults aged 18 to 24 years who were also university students. A prospective study design with two assessment points over a period of one year was used to address the specific objectives and relevant research questions (discussed in Chapter 1). This chapter outlines the methodological aspects of ethical considerations, study design, sample size, recruitments, questionnaire development, data management, derivation of measures and data analysis plan relevant to the research project.

3.2 Ethical considerations

This study adhered to the Guidelines of the ethical review process of The University of Queensland and the National Statement on Ethical Conduct in Human Research. All participants provided written informed consent before commencing Wave 1 to contribute to both the Waves. Ethics approval was obtained from The University of Queensland Behavioural and Social Sciences Ethical Review Committee (Ref: 2015000860, 1/04/2015; Amendment- 31/07/2015; Amendment- 29/09/2016). The approval form can be found in Appendix A: A1-A3.

3.3 Study design

A prospective study design over a period of one-year with two assessment points was used. Cross-sectional studies are useful to generate prevalence data and identify potential factors associated with PA and SB. With cross-sectional data, it is, however, not possible to examine potential trajectories in PA and SB and to identify factors associated with changes in these behaviours over time (Rhodes et al. 2017). As such, a prospective study with two waves was conducted over a period of one year, which was the most pragmatic option for data collection given the limited timeframe in a PhD project.

3.4 Sample size calculation

Sample size calculation was based on PA, which was the main focus of the research project. In order to estimate prevalence of young adults' activity behaviours with a 5% margin of error and 95% confidence interval, it was determined that the study needed a total of 345 participants to achieve a power of 80% with the proportion of physically active students as 66% from an earlier study in adolescents in Dhaka City, Bangladesh (Khan et al. 2017). In order to examine changes in PA levels between the two waves of the research project, a power calculation was conducted with the obtained sample size of 345. The prospective study with n=345 was found to be over-powered (power=96%) to detect a small effect size (assumed) in changes in PA levels across the two waves. To ensure that the Wave 2 data collection provided a minimum sample size of 345 to offer valid prevalence estimates, the sample size was adjusted to allow for an attrition rate of 40% (assumed), with a target of 575 to begin with at Wave 1.

3.5 Recruitment of participants

Participants were undergraduate students from six universities in Dhaka city, the capital of Bangladesh. The University setting provided a pragmatic means by which to access and track young adults over time. Difficulties with tracking baseline participants in a longitudinal study may increase the risk of attrition during follow-up (Dolton 2003; Farrington 1991), which in turn can result in substantial bias in analysis of outcomes (Dolton 2003). With no accessible national databases of young adults in Bangladesh, recruiting and following-up a randomly selected volunteer cohort of such a population can be very challenging, partly because many may enter in the labour market or may change their residence to migrate to another place. Choosing an institution-based student cohort allowed pragmatic data collection with relative ease of access to the participants.

According to the University Grant Commission (UGC), Bangladesh, there were 49 universities in Dhaka during 2014/15 when the study was conceptualised; nine public and 40 private (University Grants Comission of Bangladesh n.d.). From the list of universities, eight (three public, five private) were chosen based on their size, diversity of students, geographical convenience, and connection with the PhD candidate and the principal advisor. These universities were invited to participate in this study, either through email or via personal communication. Six (three public, three private) agreed to participate. After obtaining the gatekeeper approvals from the university authority, the candidate consulted

with the institution nominated representatives (lecturers) for a suitable date and time to access the students in the classroom to invite them formally to participate in the study. Students were eligible to participate based on the following inclusion criteria: i) undergraduate student, ii) aged 18 to 24 years, and ii) permanent resident of Bangladesh. Exclusion criteria were: i) aged >24 years, ii) international student, or iii) participant of the pilot study.

Students from multiple undergraduate programmes (i.e., science, biological science, humanities, business and engineering) were recruited from first, second and third-year to facilitate a follow-up data collection in the following year when the study participants were in second, third and fourth-year, respectively. Fourth-year students were not included at Wave 1 as they were unlikely to be available at the universities for follow-up at Wave 2. A total of 16 classrooms (seven from public universities and nine from private universities) were visited to recruit the participants (Figure 3.1).

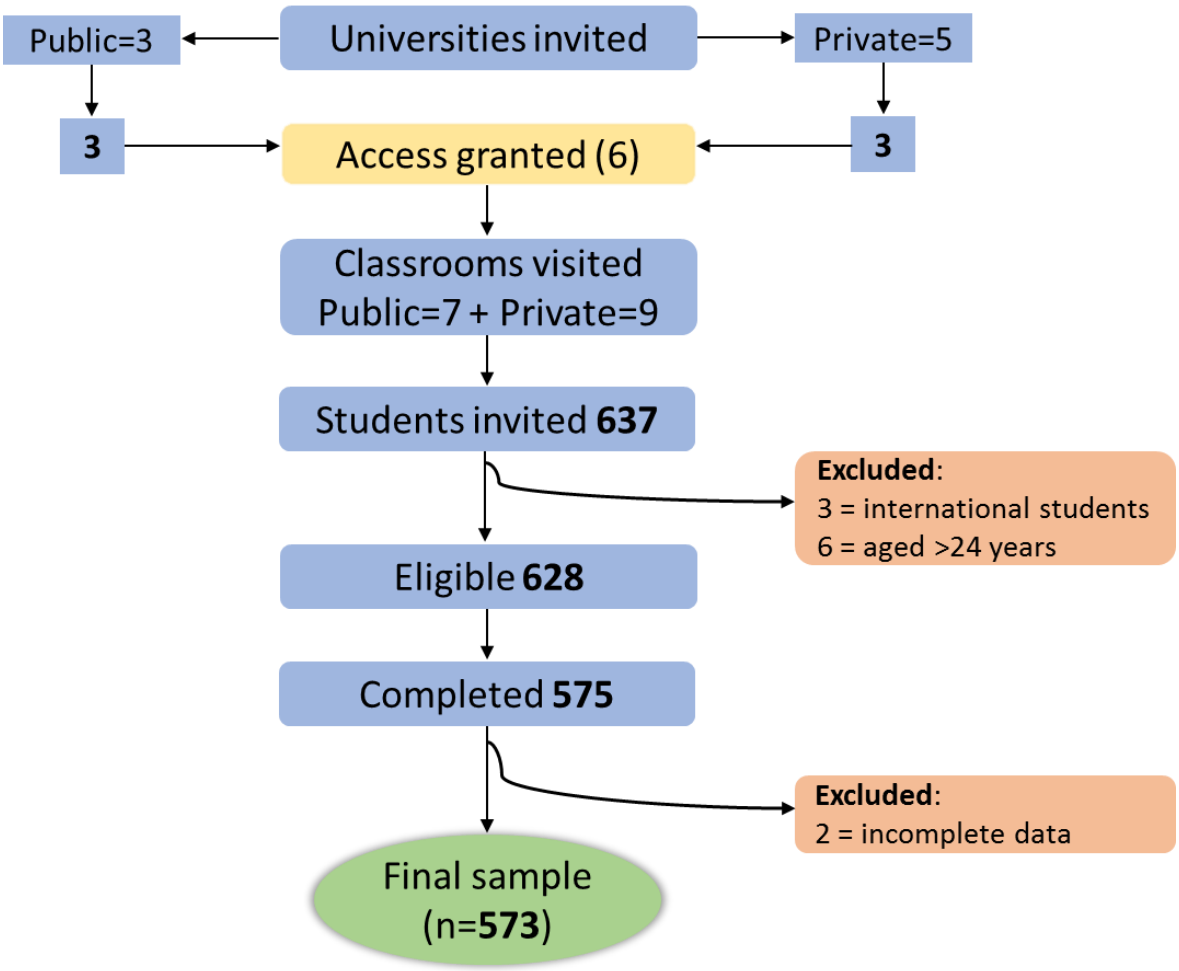

Figure 3. 1: Flow diagram of the recruitment process at Wave 1, 2015

The candidate explained the study including its context, aims and objectives to the potential participants in their classroom. The students were informed that there was no monetary or other incentives to participate as well as no anticipated risks of participation. The students were also informed about voluntary nature of their participation and the option of leaving the study at any time without any prejudice. It was also emphasised that the survey was unrelated to the participants' academic activities (e.g., assignments) and no one other than the candidate and his PhD advisors would have access to de-identified data. Consenting students then provided written informed consent. Students who were ineligible or declined to participate were free to leave or stay in the classroom at their discretion. No explanation was sought for those who declined to participate.

After completing the informed consent process, participants were instructed to provide, on the first page of the questionnaire and on the consent form, the first three letters of father's last/family name, first three letters of mother's last/family name, numeric

value of day of birth (e.g., if born on 17th of a month, participants wrote 17), and numeric value of month of birth (e.g., if born in July, participants wrote 07). This generated a unique 10-digit alphanumerical identifier to enable matching of respondents across Wave 1 and Wave 2 while maintaining participant confidentiality and anonymity. Wave 1 survey was conducted during September to December 2015, which took approximately 40-45 minutes to complete. Questionnaire used for the Wave 1 survey can be found in Appendix B: B3.

During Wave 2 (October-November 2016), the candidate re-visited the universities to administer the follow-up survey (Wave 2), again in mutually agreed class time. The students were provided with a brief version of the Wave 1 questionnaire, which took about 20 minutes to complete. Questionnaire used for the Wave 2 survey can be found in Appendix C: C2.

3.6 The instrument

The survey was administered in English. Field-testing with 30 undergraduate students (female 50%) at a university based in Dhaka city suggested no difficulties with understanding the instructions and completing the survey (discussed in details on section 3.6.2).

3.6.1. Questionnaire development

A preliminary draft (draft 1) questionnaire was developed by reviewing items used in empirical literature on PA and SB in young adults and the general population in low- and middle-income countries (LMICs). The literature search was extended to young adults in other developed countries where there was little information relevant to the conceptual framework of the Socio-Ecological Model (SEM). Consistent with the research objectives, question items were chosen to assess prevalence and patterns of PA and SB, psychosocial wellbeing and individual-level characteristics. The socio-cultural aspects of Bangladesh were considered before selecting items for the draft questionnaire.

The draft questionnaire (draft 1) was administered to four non-native English-speaking individuals at The University of Queensland School of Health and Rehabilitation Sciences. After completing the questionnaire, these individuals were requested to provide general feedback on the structure, presentation, language and instructions of the questionnaire. The candidate and his advisors had a follow-up discussion with these

individuals about various aspects of the questionnaire. Based on feedback from the participants, a short PA efficacy scale was included, which had fewer items compared to the one used in draft 1. Following the comments from the participants, items on socio-demographics were moved from the starting section to the end section of the questionnaire. There were no issues with understanding English and instructions to complete the survey. The participants provided useful feedback on wording of some of the items, which were revised accordingly. For example, instead of ‘neighbourhood streets are too dark at night’, they suggested to use ‘streets are not well lit at night in my neighbourhood’. These feedbacks were helpful to make the questionnaire more user friendly.

The revised questionnaire (draft 2) was presented to members of the candidate’s Confirmation Committee at The University of Queensland School of Health and Rehabilitation Sciences. Following the recommendations of the Confirmation Committee to extend the assessment on PA, additional items about walking time and incidental activity during work and household chores were incorporated in the revised draft (draft 3) (Figure 3.2).

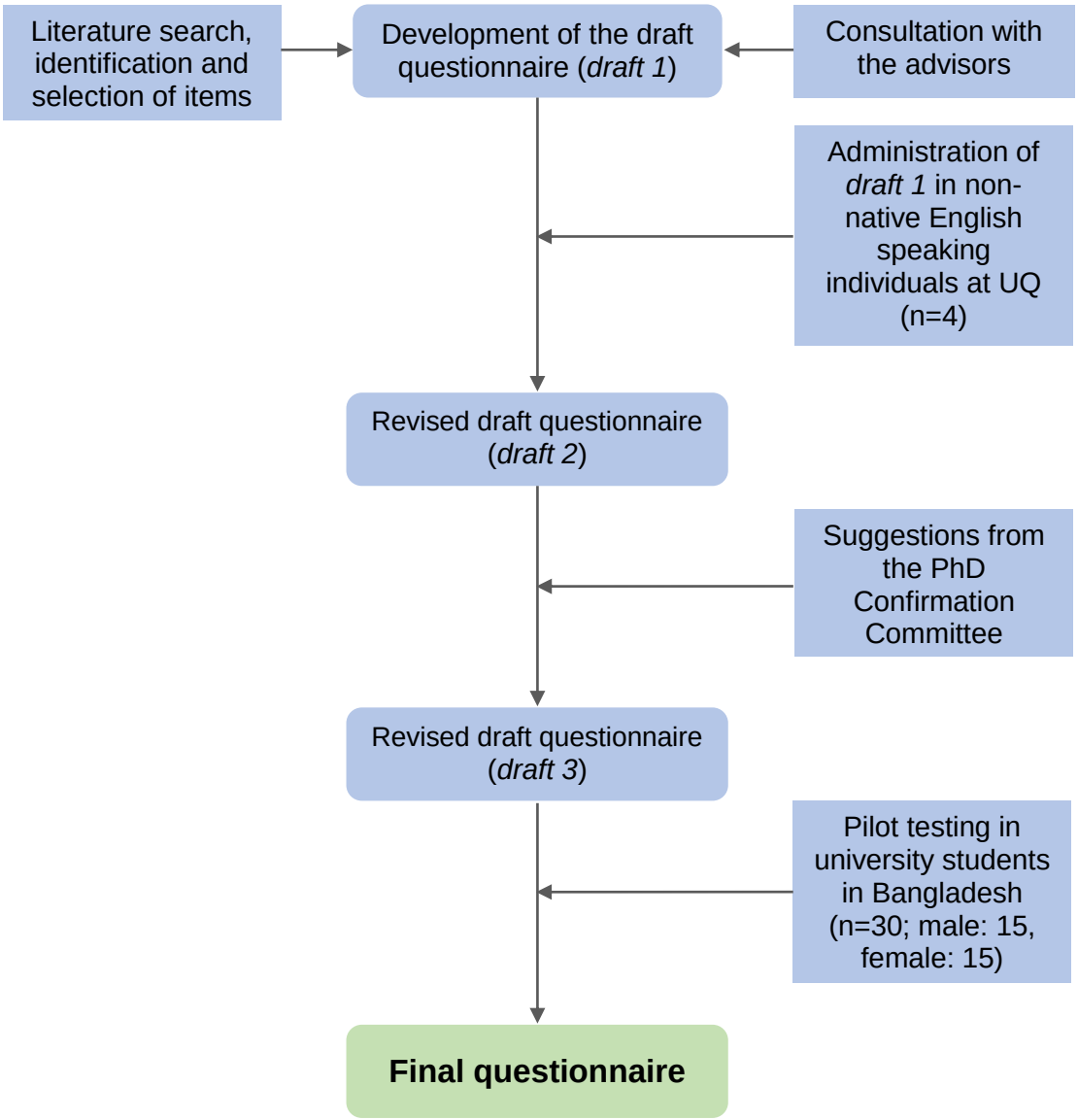

Figure 3. 2: Flow diagram of questionnaire development process

3.6.2 Pilot test and finalisation of the questionnaire

The aim of the pilot was to evaluate feasibility and acceptability of administering the questionnaire in university students in Bangladesh. The revised draft questionnaire (draft 3) was piloted in a small sample of 30 undergraduate students (50% female) of a university based in Dhaka city, Bangladesh (Figure 3.2). A local contact person (university lecturer) piloted the draft questionnaire in an undergraduate classroom. After completing the questionnaire, the participating students were asked to comment on any difficulties in understanding the written instructions, instances where the items (and words) were unclear, difficult to understand, irrelevant in context to young adults in Bangladesh, socio-

culturally inappropriate, use of English language, and time taken to complete the questionnaire. Pilot study participants completed the questionnaire within 40 minutes. Based on pilot study participants' feedback, 'yoga' was included and 'calisthenics' was replaced by 'aerobics' in the item about types of physical activities. A number of visual representations of common leisure-time PA (e.g., cricket, soccer) and SB (e.g., screen-use, reading) were included at the first-page of the questionnaire. None of the participants of the pilot study raised any concern in completing the questionnaire in English. Based on the comments of the pilot study participants, the questionnaire was finalised (final questionnaire).

3.7 Measures

An overview of the measures including activity behaviours, psychological, social, wellbeing, lifestyle behaviours and sociodemographic characteristics assessed in the research project are presented in Table 3.1.

3.7.1 Main activity behaviours

The primary outcome variables of this study were PA and SB. Accurate measurement of PA and SB is difficult and challenging as they are complex multidimensional exposures (Schmid & Leitzmann 2014). Measurements of PA and SB can be grouped into two major types: subjective measurement or self-reported methods (e.g., questionnaire, interview, diary), and objective or direct measurement of activity using different instruments (e.g., pedometer step counts, accelerometer that uses sensor-assessed technology to measure movement). Though objective measurements may provide more accurate data than subjective measurements, they may not be feasible for use in large epidemiological studies because of the cost involved or the possibility of loss or failure to return of the device (Lee & Shiroma 2014; Schmid & Leitzmann 2014). Using an objective measure may especially be challenging for an unfunded PhD research project in resource-limited countries such as Bangladesh. Subjective measures, in contrast, are often used in epidemiological studies as they are relatively cost-effective and pose minimal burden on participants (Blair & Czaja 2014). A number of questionnaires are available to subjectively assess PA.

The International Physical Activity Questionnaire (IPAQ) is a commonly used self-reported instrument to asses PA (Craig et al. 2003). Though the IPAQ long form (31 items)

captures PA data from a range of activity domains, it is lengthy and complex (de Courten 2002). The IPAQ is also available as a short form with nine items; however, it does not allow capturing PA from a multi-domain perspective and evaluates only total amount of time spent doing different intensities of PA over the last seven days (de Courten 2002). PA can take place in different contexts such as during leisure, at work or while commuting (Booth 2000). It is therefore essential to assess domain-specific PA to promote an active lifestyle, which is not possible with the IPAQ-short form.

The GPAQ that was developed by the World Health Organisation (WHO) (Armstrong & Bull 2006; Bull et al. 2009), captures PA data across three activity domains (i.e., work, recreation or travel) and is substantially shorter than the IPAQ long form (Wanner et al. 2017). The first version of the GPAQ (GPAQv1) had 19 questions. The reliability and validity of the GPAQv1 were assessed among adults in nine countries, with fair to substantial reliability in Bangladeshi adults and acceptable concurrent validity with the IPAQ, though it demonstrated poor criterion validity with pedometer data (Armstrong & Bull 2006; Bull et al. 2009). The GPAQv1 was subsequently reviewed and a shorter version (GPAQv2 with 16 items) with improved wording (for ease of understanding) was used by the WHO STEPwise approach to surveillance (STEPS) program worldwide (Armstrong & Bull 2006; Bull et al. 2009). The GPAQv2 is commonly referred to as the GPAQ by the WHO. It has been successfully used in more than 100 countries globally including Bangladesh, mainly through the STEPS program (World Health Organization n.d.-c). The GPAQ has high acceptance among respondents, is easy to administer, is suitable for young people (aged >10 years) and provides acceptable measurement with low cost (Schmid & Leitzmann 2014).

The typical administration method of the GPAQ is a face-to-face interview, conducted by trained interviewers; however, this is likely to introduce 'high interviewer bias' such as socially desirable answers even with small verbal reinforcements (Bowling 2005; Hildum & Brown 1956). The overall cost involved in using an interviewer administered face-to-face protocol may not be feasible where studies have limited resources such as this. Moreover, a face-to-face protocol may not be time efficient (Wanner et al. 2017). For example, with a face-to-face protocol, participants are required to meet and interview individually, which may be highly time consuming (Oltmann 2016). Given this, the GPAQ self-administered format is often used in European countries to save cost and time (Wanner et al. 2017). A self-administered method of the GPAQ (English version) produced comparable reliability (r_s=0.61 vs. 0.63 for self vs. interviewer) and

validity (r_S=0.30 for self and 0.46 to the interviewer) with interviewer-administration model in adults in Singapore (Chu et al. 2015). Considering comparable reliability, validity, and other pragmatic issues (e.g., logistics, cost of survey), a pragmatic decision was made to use the GPAQ self-administered method in this research project.

3.7.1.1 Physical activity

The GPAQ asks participants to report '*how many days*' in a typical week and '*how much time*' (in hours and minutes) in a typical day is spent doing PA for at least 10 minutes continuously (one bout) (World Health Organization 2012). Participants are asked for this information for each of three PA domains: work (e.g., study, paid and unpaid work, household chores, and seeking employment), transport (e.g., walking or using a bicycle for commuting) and recreation (e.g., sports, fitness or leisure) (World Health Organization 2012). Within the work and recreation domains, questions assess both vigorous- (requiring hard physical effort and causing a large increase in breathing or heart rate) and moderate-intensity (requiring moderate effort and a small increase in breathing or heart rate) PA (World Health Organization 2012). In the transport domain, only walking and cycling for transport are assessed: this is considered as moderate-intensity PA (World Health Organization 2012).

3.7.1.2 Sedentary behaviour

The GPAQ uses a single item to ask participants to report the total time spent sitting or reclining (excluding sleeping) during a typical day (Bull et al. 2009). As other research has indicated that adolescents and young adults are more sedentary on weekend days than weekdays (Arias-Palencia et al. 2015; Khan & Burton 2016), the single question of the GPAQ was split into two to assess behaviour for each of a typical weekday and a weekend day.

3.7.2 Other activity behaviours

To understand domestic and incidental PA, which are not explicitly included in the GPAQ, 10 activity items were included in the questionnaire. The items were: (i) shopping (grocery, clothes); (ii) house cleaning (kitchen/ bathroom/ bedroom); (iii) house maintenance and outdoor cleaning; (iv) washing clothes and hanging outside; (v) ironing clothes; (vi) food preparation and serving; (vii) dish washing; (viii) childcare; (ix) taking care of the elderly

person(s) in the family and (x) stair climbing. There was an open-ended “other” option so that the participants could indicate any other household activities they might have participated in. Participants reported cumulative time spent (with no minimum bout limit) in each of these activity items in a typical week.

Walking is considered the most common, accessible, popular and sustainable form of PA among adults (Lee & Buchner 2008; Saelens et al. 2003). To get further information on walking behaviour, the participants were asked an additional question to report time spent in walking for any purpose on a usual weekday and a weekend day.

Participants were also asked to report about whether they regularly participate in organised team sports (e.g., club cricket at university). Participants were asked to report the total time spent in organised sports during a typical week if they answered ‘yes’. Participants were also asked about the frequency of participation in each of 18 specific culturally appropriate leisure-time PA (LTPA) with response options of ‘daily’, ‘2–3 times a week’, ‘at least once a week’, and ‘none’. The specific LTPA items were: cricket, football, basketball, bicycling, jogging/running, badminton, table tennis, gym, using stationary exercise machine (e.g., treadmill), aerobic exercise (cardio machines, kickboxing), dancing, swimming/water exercise, yoga, karate/judo/martial arts, bowling, hockey, tennis and volleyball. Participants also had the option to respond to an open-ended question to identify any other specific sports or recreational activities. Seven of these items were based on an earlier research on adolescent PA in Bangladesh (Khan et al. 2017), with an additional 11 age appropriate items.

Seven age appropriate non-occupational SB [e.g., watching television (TV), using computer, tablet, smartphone for fun] were added to the questionnaire to obtain more information than what is provided by the GPAQ. The participants were asked to report total time (hours and minutes) spend sitting or reclining in each of these activities separately on a typical weekday and a weekend day. Participants were also asked to report time spent using each of the following common mode of transports: bus, car, auto rickshaw and human peddled rickshaw while travelling to the university (one way) in a typical weekday.

3.7.3 Psychological variables

3.7.3.1 Physical activity efficacy

Perceived efficacy for PA was measured using a five-item scale (Schwarzer & Renner 2009). The items asked about the participants' confidence to overcome barriers such as having worries (or problems), feeling depressed, tensed, tired, and lack of time (too busy) to persistently engage in PA. The response options were: 1='very uncertain'; 2='rather uncertain'; 3='rather certain' and 4='very certain'. Though the original instrument refers to 'physical exercise', for this research project the term '*physical activity*' was used instead of physical exercise to match the GPAQ wording. The original scale has demonstrated high internal consistency in general adults (Cronbach's alpha=.88) (Schwarzer & Renner 2009). The scale has moderate correlation with exercise intention (*r*=.33) and exercise behaviour scales (*r*=.39) at six months follow-up, which supports its validity (Schwarzer & Renner 2009). The scale has previously demonstrated high internal consistency among young adults in LMICs (Cronbach's alpha=.85) (Fincham et al. 2015) and in an Asian adult population (Cronbach's alpha=.89) (Poomsrikaew et al. 2012).

3.7.3.2 Physical activity outcome expectations

Respondents' positive outcome expectations were assessed using five statements, selected from the Benefits of Physical Activity Scale (Sallis et al. 1989). The items were: If I participate in regular PA or sports, then I will (i) improve my physical fitness; (ii) improve my appearance; (iii) improve my health; (iv) reduce my risk of poor health; and (v) help manage my weight. Participants were asked to indicate to what extent they agreed or disagreed with each statement using response options of 1='strongly disagree'; 2='disagree'; 3='unsure'; 4='agree' and 5='strongly agree'.

3.7.3.3 Perceived importance of physical activity

Participants were asked a single question 'How important is physical activity in your life?' with a 6-point Likert-scale with response values of 0='not at all important'; 1='somewhat unimportant'; 2='neutral'; 3='somewhat important'; 4='important'; and 5='very important'.

3.7.3.4 Perceived environmental barriers to physical activity

Perceived environmental barriers to PA items were selected from previous PA research in LMICs with young adults (Abdullah et al. 2016; Musaiger et al. 2014; Oyeyemi et al. 2011) and in the general population (Ariffin & Zahari 2013; Churangsarit & Chongsuvivatwong 2011; Ding et al. 2011; Hino et al. 2011; Jáuregui et al. 2016; Parra et al. 2011; Ranasinghe et al. 2016; Sugiyama et al. 2014). Seven opinion statements were used: (i) The weather is often too bad to do physical activity; (ii) There are no convenient places (e.g., parks or open fields) nearby for physical activity; (iii) It is not safe to walk in my neighbourhood; (iv) My neighbourhood is not clean and tidy; (v) The footpaths are not in good condition in my neighbourhood; (vi) There is heavy traffic in my neighbourhood; and (vii) Streets are not well lit during night in my neighbourhood. Respondents were asked to indicate to what extent they agreed or disagreed with each statement with response options of 1='strongly disagree'; 2='disagree'; 3='unsure'; 4='agree' and 5='strongly agree'.

3.7.4 Social variables

3.7.4.1 Social support for physical activity

Social support for PA scale included 10 items asking about the frequency of support or criticism received about PA from friends, family or members of the household over the past three months. The 10 items were from the Social Support for Exercise Survey Scale developed by Sallis and colleagues (Sallis et al. 1987). To be consistent with the GPAQ wording, 'physical exercise' was replaced by 'physical activity'. Example items include: 'done physical activity with me'; 'offered to do physical activity'; 'complained about the time I spend doing physical activity'. Response options were: 'never'; 'rarely'; 'a few times'; 'often'; 'very often' and 'not applicable'.

3.7.4.2 Professional advice on physical activity

Participants were asked whether they had received any advice from a physician or healthcare professional over the past 12 months to participate in regular PA with three response options: 'yes', 'no', and 'cannot recall now'.

3.7.5 Health, wellbeing and lifestyle variables

3.7.5.1 Physical health

Self-rated health data were collected using a single item based on the SF-12: 'In general how would you rate your current health?', with response options being 'excellent'; 'very good'; 'good'; 'fair' and 'poor' (Jenkinson et al. 1997). Participants were asked about frequency of experiencing each of five specific physical health conditions during the past month: muscular pain, headaches, muscular tension, nausea and stomach cramp with responses using a 5-point Likert scale ranging from 0 to 4 (0 = 'not at all' to 4 = 'almost always').

3.7.5.2 Psychological health

The short form of the Kessler Psychological Distress Scale (K6) was used to assess psychological distress (Kessler et al. 2002). It consists of six items, which asked the participants 'during past four weeks how much of the time did you feel – (i) so sad nothing could cheer you up; (ii) nervous; (iii) restless or fidgety; (iv) hopeless; (v) that everything was an effort and (vi) worthless'. Participants were asked to rate how frequently they felt these on a scale of 0 to 4, where 0 = 'none of the time'; 1 = 'a little of the time'; 2 = 'some of the time'; 3 = 'most of the time' and 4 = 'all of the time'. The K6 is a reliable and validated self-report tool that assesses general psychological distress rather than specific symptoms (Kessler et al. 2002; Kessler et al. 2010). It has been used in many large epidemiological studies including the WHO's World Mental Health Survey (Furukawa et al. 2003; Kessler et al. 2010).

Five additional items were used to assess the frequency of experiencing during past month: (i) stress, (ii) depression, (iii) anxiety, (iv) trouble concentrating and, (v) sleep difficulties. Each of these were assessed on a 5-point Likert scale ranging from 0 to 4 (0 = 'not at all' to 4 = 'almost always'). Information on overall life satisfaction was collected using a 10-point Likert scale where 1 indicated 'not satisfied at all'; 5 'neither satisfied nor dissatisfied', and 10 'highly satisfied'.

3.7.5.3 Health behaviours

Participants were asked if they were a 'non-smoker', 'current smoker', 'occasional smoker' or 'past smoker', and for the latter two responses, the number of cigarettes smoked in a usual day/week. Participants were asked about alcohol consumption with response options of: 'I never drink alcohol'; 'I don't drink now, but I used to'; 'I drink occasionally' and 'I drink regularly'. The questionnaire also included an item on time spent sleeping during each of a typical weekday and a weekend day (hours and/or minutes). The questionnaire included items on height and weight, which were used to compute body mass index (BMI), which was grouped into one of three weight categories based on criteria from the WHO: healthy weight (<18.50 kg/m^2); underweight (18.50-24.99 kg/m^2), and overweight and obese (≥25.00 kg/m^2) (World Health Organization n.d.-b).

Participants were asked to report the number of servings consumed of each of the following eight common and popular food types during past seven days: (i) fast food; (ii) fried food; (iii) Chinese/Thai food; (iv) chocolate/ lolly/ candy; (v) ice-cream; (vi) bakery food; (vii) fresh fruit and (viii) vegetables/green salad. Participants were also asked to report frequency of consumption of sugary drinks (e.g., Coke, Pepsi, excluding diet Coke or cola type soft drinks) in the past seven days with response options: 'none'; '1-2 glasses'; '3-4 glasses'; '5-6 glasses'; '7-9 glasses'; '10-13 glasses' and '14+ glasses'. Participants were asked to report (i) the number of days they had breakfast and (ii) brought homemade lunch at the university in the past seven days. Dietary habit related questions were adapted from a questionnaire previously used in adolescents in Bangladesh (Khan et al. 2017).

3.7.6 Socio-demographics and socio-economic variables

Participants were asked to report age (in complete years), gender, marital status (single, married, divorced, widowed, and separated); having children (yes/no), enrolled undergraduate program (Science, Biological Science, Humanities, Engineering, Business, and other), and year of study (1st, 2nd and 3rd). Participants were asked to report monthly gross household income [≤10,000 Bangladeshi Taka (BDT), 10,001-20,000, 20,001-30,000, 30,001-40,000, 40,001-50,000, 50,001-70,000, 70,001-100,000, 100,001-150,000, 150,001-200,000 and >200,000 BDT]; source of financial support for study (i.e. parents, relatives, self through part-time job); employment status – paid casual/part-time/full-time job (yes/no), and total time working per week (in case answer was yes). Participants were also asked to report their parents' highest level of education and their current main

occupation [adapted from the 2011 Bangladesh Demographic and Health Survey (Bangladesh Demographic and Health Survey 2013)]. Participants were asked to report their living arrangement ('living alone'; 'with parents'; 'with husband/wife'; 'with other family members'; 'with friends/colleagues' and 'living with others') and their housing type ('own house/flat'; 'rented house/flat', 'university accommodation/hall' and 'shared house/student mess). The questionnaire also included items on access to private motor vehicle ('always'; 'sometimes'; 'occasionally'; 'no access') and availability of each of TV, computer, laptop or other small screen (tablet) in bedroom (yes/no).

3.8 Survey items for Wave 2

Wave 2 survey used a sub-set of Wave 1 questionnaire. This did not include items, which were unlikely to change over one year including socio-demographics/socio-economic factors. Table 3.1 provides an overview of the items of Wave 1 and Wave 2 surveys.

The GPAQ was retained in the Wave 2 questionnaire as PA and SB were the primary outcomes. Items to assess time spent on walking, frequency of participation in LTPAs, and frequency and time spent in organised team sports, time spent on specific non-occupational SB and mode of transport were also retained.

To address the study objective 2 about individual level correlates PA and correlates of changes in PA, efficacy scale and perceived importance of PA were retained in Wave 2 survey. To address the study objective 3 about examining the association of PA and SB with psychological health, the K6 scale, and items on sleep difficulties, depression and anxiety were retained. The item on overall life satisfaction was also retained in Wave 2 survey. Other items retained in the Wave 2 survey were height and weight (to compute BMI, which was considered to have the potential to change during the year), and items on having a TV, desktop computer, laptop, or other small screen (i.e., tablet) in bedroom.

Table 3. 1: Variables used in Wave 1 and Wave 2

Variables		Wave 1	Wave 2
Main activity behaviours			
	Physical activity (GPAQ)	√	√
	Sedentary behaviour (GPAQ-adapted)	√	√
Other activity behaviours			
	Time spent walking (including small bouts)	√	√
	Time spent in organised sports	√	√
	Frequency of participation in leisure-time physical activities	√	√
	Time spent in specific sedentary pursuits	√	√
	Time spent in commuting using standard mode of transport	√	√
	Incidental work and household activities (total time)	√	×
Psychological variables			
	Physical activity efficacy	√	√
	Perceived importance of physical activity	√	√
	Activity outcome expectations	√	×
	Perceived environmental barriers to activity	√	×
Social variables			
	Perceived social support for activity	√	×
	Professional advice for activity	√	×
Health, wellbeing and lifestyle variables			
General health and health behaviour			
	Height	√	√
	Weight	√	√
	Time spent sleeping	√	×
	Cigarette smoking	√	×
	Alcohol consumption	√	×
	Dietary habits	√	×
Physical health			
	Physical health conditions (specific items)	√	√
	Health condition restricting from physical activity	√	√
	Perceived current physical health	√	×
Psychological health			
	Non-specific psychological distress	√	√
	Psychological health conditions (specific items)	√	√
	Perceived life satisfaction	√	√
Socio-demographics/socio-economic variables			
	Television/ computer/ laptop/ small screen at bedroom	√	√
	Age	√	×
	Gender	√	×
	Program enrolled	√	×
	Year of study	√	×
	Marital status	√	×
	Having children	√	×
	Parents' education	√	×
	Parents' main occupation	√	×
	Monthly household income (gross)	√	×
	Living arrangement	√	×

	Housing type	√	×
	Car ownership	√	×
	Source of financial support for study	√	×
	Doing any paid job; if yes total time working for	√	×
	Most of the time spent during high school	√	×

3.9 Data management

After receiving the completed surveys, the first page of the survey (the consent form, which contains identifiable code) was removed before data entry, and securely filed separately from the questionnaire. Returned completed questionnaires were checked for consistency, unlikely or out-of-range or missing values, and were coded before being manually entered into the database.

Non-plausible values for PA/SB were defined as number of days exceeding 7 days per week, and hours per day exceeding 24 hours, and such cases were not included in the final database. Two such cases were identified, and subsequently excluded from the database. In cases where activity reported for any domain or intensity that exceeded 16 hrs/day, data were truncated at 16 waking hrs/day as per the GPAQ data analysis protocol (Bull et al. 2009).

Wave 2 data were checked, coded, and truncated following the same data management protocol. The 10-digit alphanumeric code was used to match Wave 2 data with Wave 1 data. De-identified data were used in the analyses to ensure participants' anonymity and confidentiality. Only the candidate and the advisors of the project had access to the survey data, as stipulated in the approved ethics.

3.10 Derivation of measures

Physical activity: Consistent with the GPAQ data analysis guidelines (World Health Organization 2012), all PA data were converted into minutes, and were multiplied by their corresponding number of days. Vigorous activity minutes were multiplied by two given the higher intensity than moderate activity (World Health Organization 2012). The time spent in vigorous activity (weighted) and moderate activity were summed to obtain a composite measure of the total mins/week spent doing moderate-to-vigorous PA (MVPA). The following method was used:

i) MVPA in work domain (mins/week): vigorous activity mins/day × number of days/week × 2 + moderate activity mins/day × number of days/week
ii) Moderate-intensity PA in transport domain (mins/week): moderate activity mins/day × number of days/week
iii) MVPA in leisure domain (mins/week): vigorous activity mins/day × number of days/week × 2 + moderate activity mins/day × number of days/week
iv) Total MVPA (mins/week) = i + ii + iii

Participants were then categorised as meeting or not meeting the WHO recommendations using the criterion of ≥150 mins/week of MVPA (World Health Organization 2010).

Walking data were converted to minutes, and daily walking time was computed as: [(weekday time × 5)+(weekend day time × 2)]/7. This was used as a continuous variable.

Sedentary behaviour: Total SB (mins/day) was computed from GPAQ data on SB time during a typical weekday and a weekend day. The following method was used:

Total sedentary time (mins/day) = [weekday sedentary time (mins/day)×5 + weekend day sedentary time (mins/day)×2]/7

Using the same method, total time spent (mins/day) in each of the seven specific non-occupational SB (e.g., TV-time, computer time, travel time) were also computed from weekday and weekend day data and were used as continuous variables.

Currently, there is no consensus threshold at which a person is defined as sedentary. Daily sitting for more than eight hours (480 mins) has been shown to increase the risk of all-cause mortality significantly (Chau et al. 2015). This threshold (≥480 mins/day) has been used to define high SB in other research in Asia (Win et al. 2015) and Australia (Bennie et al. 2016). SB was, therefore, dichotomised as 'low' and 'high' based on participants spending <480 mins/day and ≥480 mins/day, respectively.

Physical activity efficacy: The factor structure and internal consistency of the PA efficacy scale was assessed. An exploratory factor analysis with varimax rotation confirmed the unidimensionality of the five items examined and offered a one-factor solution, which accounted for 52% of the variance. Cronbach's alpha was 0.85. Item

scores were summed to generate a total PA efficacy score (range: 5-20) with a high score representing high efficacy.

Physical activity outcome expectations: The factor structure and internal consistency of the PA outcome expectations scale was assessed. An exploratory factor analysis with varimax rotation confirmed the unidimensionality of the five items examined and offered a one-factor solution, which accounted for 56% of the variance. Cronbach's alpha for the modified scale was 0.79. Item scores were summed to generate an outcome expectation score ranging from 5 to 25 with a high score representing positive outcome expectations.

Perceived environmental barriers to physical activity: The seven items that were used to assess perceived environmental barriers did not result in a single factor solution during the exploratory factor analysis, and as such, they were treated as individual items. Given the skewed nature of responses, items were collapsed into two categories of agreement [4 or 5] and non-agreement [1, 2 or 3, includes disagreement and 'unsure' category] to facilitate analysis and interpretable findings.

Psychological distress: The factor structure and internal consistency of the K6 scale was assessed. An exploratory factor analysis with varimax rotation confirmed the unidimensionality of the scale in this current population and offered a one-factor solution, which accounted for 58% of the variance. Cronbach's alpha was 0.85. The item scores were summed to generate a total K6 score (range: 0-24) with a high score representing more distress. A score of ≥13 in K6 scale represents serious psychological distress (Kessler et al. 2002; Kessler et al. 2010). This cut off, however, has not been validated in Bangladeshi population. The total K6 score was used as a continuous variable to examine its association with PA and SB.

Sleep difficulties: Frequency of sleep difficulties was measured with a single scale ranging from 1 to 5, where 1 = less frequent and 5 = more frequent. Because of non-normal distribution of these data, to facilitate interpretable statistical analyses, responses from this single item were collapsed into three difficulty categories: rarely [1 or 2]; sometimes [3] and often [4 or 5]. A similar approach has been used in previous large-scale research (Rayward et al. 2017).

Social support for physical activity: The factor structure and internal consistency of the social support for PA scale was assessed. An exploratory factor analysis with varimax rotation confirmed the unidimensionality of the 10 items examined and offered a one-factor

solution, which accounted for 91% of the variance. Cronbach's alpha for this scale was 0.87. The item scores were summed to generate a total social support score (range: 6-36; one item was reverse coded) with a high score representing high level of social support from family and friends for PA.

The following table (Table 3.2) summarises the scales with multiple items used in this research project with number of items, variance accounted for by factors and internal consistency of the items:

Table 3. 2: Summary factor analysis and internal consistency of wellbeing and correlate scales used in the research project

Construct	Items (N)	Scores (Range)	Variance accounted for	Cronbach α	Source/ Adapted from
Psychological distress	6	0-24	58%	0.85	Kessler 6 psychological distress scale (Kessler et al. 2002)
Physical activity efficacy	5	5-20	52%	0.85	Physical exercise self-efficacy scale (Schwarzer & Renner 2009)
Activity outcome expectations	5	5-25	56%	0.79	Benefits of physical activity scale (Sallis et al. 1989)
Social support for activity	10	6-36*	91%	0.87	Social support for exercise survey scale (Sallis et al. 1987)

* one item was reverse coded

3.11 Data recoding

Data recoding was performed on a number of explanatory variables to optimise interpretable analyses. For example, due to a relatively narrow range (18 to 24 years), age was grouped into two categories: 18 to 20 and 21 to 24 years. BMI, which was computed from self-reported height and weight was grouped into one of three categories based on criteria suggested by the WHO: normal (<18.50 kg/m^2); underweight (18.50-24.99 kg/m^2) and overweight/obese (≥25.00 kg/m^2) (World Health Organization n.d.-b). Monthly gross household income, which was used as a proxy socio-economic status indicator, was categorised into one of four groups: (i) ≤20,000 BDT; (ii) 20,001-40,000; (iii) 40,001-70,000 and (iv) >70,000 BDT.

3.12 Statistical data analyses

To obtain the descriptive profile of the study participants, descriptive statistics (e.g., frequencies, means, standard deviations) were produced for socio-demographic and economic characteristics. These variables were used in subsequent analyses to address the objectives of the research project.

Objective 1: To assess the prevalence and socio-demographic patterns of PA and SB, cross-sectional data from Wave 1 was used. Univariate analyses were performed to explore the prevalence of PA and SB. Due to the skewed distribution; MVPA mins/week and sedentary time mins/day were summarised using medians with interquartile ranges. In Bangladesh, males and females can be considered as two different population groups in relation to opportunities and access to various activities, which maybe guided largely by socio-cultural customs and norms, and gender roles (Goetz 2013). Gender based differences in the prevalence and patterns of participation in PA were explored using Chi-square test. Non-parametric equality-of-medians test was used to examine gender differences between medians of MVPA mins/week. The proportion of participants meeting the WHO PA recommendations (≥150 mins/day of MVPA) (categorisation discussed in detail in section 3.10) and engaging in the different types of LTPA were computed. The prevalence of PA was further examined for any age or income differences using Chi-square test and Fisher's exact test (in a case where at least one expected cell frequency was small ≤5). The prevalence of PA was reported as a percentage with 95% confidence intervals (CIs).

For SB, the proportion of participants with high SB (≥480 mins/day, discussed in section 3.10) were computed. Given the skewness of the data, medians with interquartile ranges were used to summarise time spent in overall SB and in specific non-occupational SBs. The non-parametric equality-of-medians test was used to examine possible gender differences in median sedentary time. Using Chi-square test, the proportion of high SB was further examined for possible gender differences. The prevalence of SB was reported as a percentage with 95% CIs. Details of the statistical analyses for the prevalence and sociodemographic patterns of PA (section 4.1) and SB (section 4.2) have been discussed in Chapter 4.

Objective 2: To identify individual level correlates of PA, SB and changes in PA and SB, both cross-sectional (Wave 1) and prospective data (Wave 1 and Wave 2) were used. Perceived environmental barriers to PA were studied using Wave 1 data.

To examine how the profiles of students who 'agreed' differed from those of students with 'not-agreed', the proportion of participants agreed/not-agreed with each perceived environmental barrier item was derived, and results reviewed to identify the most common barriers. As mentioned earlier, males and females can be considered as two different population groups in Bangladesh (Goetz 2013). Hence, to examine possible gender differences in environmental barriers binary logistic regression analyses were used, adjusted for potential confounders, which were identified in the univariate analysis. Sociodemographic variables were considered as potential confounders, including: age, gender, BMI, marital status, parental education and employment/occupation status, monthly gross household income, household composition, housing type, university type, enrolled program, and year of study. Only variables that were considerably associated with the corresponding barrier item (dependent variable) in the bivariate analyses (Chi-square test) were considered for the final regression models. These confounders were examined for collinearity before entering in the regression models. Outliers and other assumptions of the models were checked and model fit was assessed before finalising the models. For each of the environmental barrier items unadjusted and adjusted odd ratios (OR) for gender with their 95% CIs were computed. Details of the statistical analyses for the perceived environmental barriers to PA have been discussed in section 5.1 of Chapter 5.

Individual level correlates of PA and SB were identified using prospective data. Due to non-normal distribution of MVPA (mins/week) and SB (mins/day) data (dependent variable), Generalized Estimating Equations (GEE) with *gamma* distribution and *log* link under *exchangeable* correlation structure was used. GEE, which is an extension of generalised linear model is useful in studies with repeated measures, and is often used to analyse longitudinal as well as other correlated data (Gary 2004; Palacio-Vieira et al. 2008). In these analyses, GEE took into account the non-independence of the dependent variable nested within the two waves. Explanatory variables which had bivariate associations with the dependent variables at ≤20% significance level [(Maldonado & Greenland 1993)] were identified and examined for collinearity. Outliers and other assumptions of the models were checked and model fit was assessed before finalising the models. To ensure that the results are easily interpretable, the regression coefficients were exponentiated into ORs using the *eform* command in Stata. Results are presented as ORs

with their 95% CIs. Details of the statistical analyses for the correlates of PA and SB have been discussed section 5.2 and 5.3 of Chapter 5, respectively.

To identify the correlates of changes in PA and SB, prospective data were used. To derive changes in PA over one-year, Wave 1 MVPA data (mins/week) were subtracted from Wave 2 MVPA data. These changes were then categorised into three groups: negligible change = ±≤60 mins/week increase/decrease; decrease = decreased by >60 mins/week, and increase = increased by >60 mins/week in PA over one year. As the dependent variable (changes in MVPA) had three categories (negligible change, decrease and increase), multinomial logistic regression analysis was used to identify the correlates of changes in PA. Explanatory variables that had bivariate associations with the outcome variable at ≤20% significance level [(Maldonado & Greenland 1993)] were identified and examined for collinearity. Outliers and other assumptions of the models were checked and model fit was assessed before finalising the model. Variables, which had insignificant associations with the outcome variable in the multivariable model at 5% level of significance, were excluded. Results are presented as ORs with their 95% CIs. The modelling with three categories for the outcome variable involved estimation of the following two equations:

i) The likelihood of '*decrease'* in PA over one-year vs. the likelihood of '*negligible change*', and
ii) The likelihood of '*increase'* in PA over one-year vs. the likelihood of '*negligible change'*.

To derive changes in SB over one-year, Wave 1 SB data (mins/day) were subtracted from Wave 2 SB data. These data were then categorised into three groups: *negligible* change = ±≤120 mins/day increase/decrease in SB; increase = increased by >120 mins/day, and decrease = decreased by >120 mins/day. The modelling of changes in SB followed a similar method as used to identify the correlates of changes in PA. Details of the statistical analyses for the correlates of change PA and SB have been discussed in section 5.4 of Chapter 5.

Objective 3: To examine the associations of PA and SB with psychological wellbeing, one-year prospective data on the K6 scale and self-reported sleep difficulties were used. As discussed in section 3.10, PA was categorised as insufficient and sufficient, and SB as high and low, which were then used to create a variable of combinations of PA

and SB: *i*) sufficient PA + low SB, *ii*) sufficient PA + high SB, *iii*) insufficient PA + low SB, and *iv*) insufficient PA + high SB. Due to normal distribution of the K6 scores (the dependent variable), GEE with *Gaussian* family and *identity* link under *exchangeable* correlation structure was used to examine effects of PA and SB on the total K6 scores. In this analysis, GEE took into account the non-independence of the K6 scores nested within the two waves. The following covariates assessed at Wave 1 were considered as potential confounders: age, gender, marital status, BMI, parental education and occupation, monthly gross household income, household composition, housing type, TV in bedroom, perceived health, sleep difficulties, smoking, alcohol consumption, fast food intake, fresh fruit and vegetable intake, non-alcoholic carbonated beverage intake, university type, enrolled program, and year of study. Potential confounding variables were identified by examining the bivariate association of the aforementioned explanatory variables with the total K6 scores at 20% significance level [as recommended elsewhere (Maldonado & Greenland 1993)]. The identified potential confounders were then examined for collinearity. Variables, which had insignificant associations with the K6 scores in the multivariable model at 5% level of significance, were excluded. Outliers and other assumptions of the models were checked and model fit was assessed before finalising the models. The associations were presented as adjusted regression coefficients (ß) with their 95% CIs.

To examine the associations of PA and SB with sleep difficulties, self-reported frequency of experiencing self-difficulties with three categories (rarely, sometimes and often) was used as the dependent variable. As discussed previously, the combinations variables of PA and SB were used. As the dependent variable had three categories and were measured at two time points, Generalized Linear Latent and Mixed Models (GLLAMM) with *binomial* family and *mlogit* link was used to examine the associations of PA and SB with sleep difficulties. GLLAMM, a nonlinear multilevel estimation procedure took into account the non-independence of sleep difficulties nested within the two waves, adjusted for potential confounders. To obtain reliable estimates from the modelling, a 10-point numerical integration with adaptive quadrature was used in the GLLAMM (Rabe-Hesketh et al. 2002). A number of variables assessed at Wave 1 were considered as potential confounders including age, gender, marital status, BMI, parental education and occupation, monthly gross household income, household composition, housing type, university type, enrolled program, and year of study, TV in bedroom, smoking, alcohol consumption, fast food intake, fresh fruit and vegetable intake, non-alcoholic carbonated beverage intake. Potential confounding variables were identified by examining bivariate

association of the aforementioned explanatory variables with the sleep difficulties at 20% significance level [as recommended elsewhere (Maldonado & Greenland 1993)]. The identified potential confounders were then examined for collinearity. Variables, which had insignificant associations with sleep difficulties in the multivariable model at 5% level of significance, were excluded. The modelling involved estimation of the following two equations:

i) The likelihood of experiencing sleep difficulties '*sometimes'* vs. the likelihood of experiencing '*rarely'*, and
ii) The likelihood of experiencing sleep difficulties '*often'* vs. the likelihood of experiencing '*rarely'*.

To ensure easy interpretability of the results, estimates of ORs with their 95% CIs for the associations were produced. Independent associations of PA and SB on sleep difficulties adjusted for the set of potential confounders were also examined. Details of the statistical analyses for the associations of PA and SB with K6 and sleep difficulties have been discussed in section 6.1 and 6.2 of Chapter 6, respectively.

All statistical analyses were performed using Stata 14 statistical software (StataCorp, Texas, USA) with the level of significance set at p <.05.

3.13 Summary

To understand the prevalence, patterns, correlates and changes of PA and SB and their relationships with psychological wellbeing of young adults in Bangladesh, a one-year prospective study with two assessment points was conducted. Participants were a convenience sample of undergraduate students recruited from six universities based in Dhaka city, Bangladesh. Data were collected using a self-administered survey, which was developed to assess participants' PA, SB, psychological wellbeing; individual-level correlates of activity behaviours, health and sociodemographic variables. Collected data were manipulated/recoded and analysed to address the objectives of the research project. The next chapters (Chapter 4 to 6) present the findings of this research project. While Chapter 4 describes the prevalence and socio-demographic patterns of PA (Research question 1) and SB (Research question 2) among young adults in Bangladesh, Chapter 5 presents the perceived environmental barriers (Research question 3) and correlates of PA (Research question 4), SB (Research question 5), and changes in PA and SB (Research

question 6) over one year. Chapter 6 presents the associations of PA and SB with psychological distress (Research question 7) and sleep difficulties (Research question 8) of young adults in Bangladesh.

Chapter 4: Prevalence and patterns of activity behaviours

Uddin R, Khan A, Burton NW. (2017) Prevalence and sociodemographic patterns of physical activity among Bangladeshi young adults. *Journal of Health, Population and Nutrition* **36**:31. doi: https://doi.org/10.1186/s41043-017-0108-y

Contributor	Statement of contribution (Chapter 4 – Section 4.1)
Riaz Uddin (Candidate)	Conception and design (50%); analysis and interpretation (50%); drafting and production (50%)
Asaduzzaman Khan	Conception and design (30%); analysis and interpretation (30%); drafting and production (30%)
Nicola W Burton	Conception and design (20%); analysis and interpretation (20%); drafting and production (20%)

Uddin R, Khan A, Burton NW. Are the young adults in Bangladesh sitting too much? [*under review*]

Contributor	Statement of contribution (Chapter 4 – Section 4.2)
Riaz Uddin (Candidate)	Conception and design (50%); analysis and interpretation (50%); drafting and production (50%)
Nicola W Burton	Conception and design (25%); analysis and interpretation (20%); drafting and production (25%)
Asaduzzaman Khan	Conception and design (25%); analysis and interpretation (30%); drafting and production (25%)

Prevalence and patterns of activity behaviours

The overarching theme of Chapter 4 is to assess the prevalence and patterns of physical activity (PA) and sedentary behaviour (SB) in university-based young adults (age 18-24 years) in Bangladesh. This chapter is composed of two sections and addresses two research questions. Using Wave 1 data, section 4.1 presents the prevalence and patterns of PA (Research question 1), while section 4.2 presents the prevalence and patterns of SB (Research question 2).

4.1 Prevalence and patterns of physical activity

This paper has been published in the *Journal of Health, Population and Nutrition*.

4.1.1 Abstract

Background: Physical activity offers physical and psychosocial health benefits that are important during young adulthood and later in life. However, little is known about the physical activity of young adults in low- and middle-income countries. The purpose of this study was to estimate the participation of physical activity in Bangladeshi young adults and to assess differences by gender, age and family income.

Methods: This cross-sectional study with a self-administered survey used a convenience sample of 575 young adults aged 18-24 years from six purposively selected universities in Dhaka City, Bangladesh. Data were collected during September-November 2015. Medians and their interquartile ranges of weekly time spent in total physical activity, and in different domains of physical activity were computed. Non-parametric equality-of-medians test was used to examine gender differences in the median values. Chi-square test and Fisher's exact test were used to examine gender differences in the prevalence of meeting physical activity recommendations, frequency of participation in different leisure-time physical activities, and differences in meeting the activity recommendations by age and family income.

Results: Seventeen percent of the participants were meeting moderate-to-vigorous physical activity (MVPA) recommendations with a significantly higher proportion of males than females (27% vs. 6%, $p<.0001$). Median duration of MVPA was significantly higher ($p<.0001$) for males [120 minutes/week (80, 190)] than females [90 minutes/week (50, 120)]. Jogging/running was the most commonly reported leisure-time physical activity, with 20% of males and 12% of females doing this at least once a week. Age and family income were not significantly associated with meeting MVPA recommendations.

Conclusions: Four out of five young adults in Dhaka City did not meet the physical activity recommendations. Additional population-based studies, including regional and metropolitan areas, and using objective measurement, are needed to understand the physical activity patterns of Bangladeshi young adults.

4.1.2 Introduction

Regular physical activity participation offers physical and psychosocial health benefits including physical fitness; healthy weight; and prevention and management of conditions such as diabetes and cardiovascular disease, stress and depression (Swift et al. 2016). Despite these benefits, a large number of people worldwide are leading an inactive lifestyle. According to a global estimation in 2010 by the World Health Organization (WHO), approximately 23% of adults aged 18 years or more did not meet the WHO recommendations of at least 150 minutes/week of moderate-intensity or 75 minutes/week vigorous-intensity activity, or an equivalent combination of moderate-to-vigorous physical activity (WHO n.d.). In the WHO South-East Asian region, 15% of adults were not meeting the WHO recommended levels of physical activity (WHO n.d.).

According to the World Health Organization (WHO), physical inactivity is the fourth leading risk factor for global mortality (Brymer & Davids 2016; Dumith et al. 2011), and evidence suggests that inactivity related deaths have increased over the years (Moniruzzaman et al. 2017). In 2008, 3.2 million of global deaths per annum were attributable to physical inactivity (Brymer & Davids 2016), which increased to 5.3 million global deaths per annum as per the most recent estimate in 2012 (Lee et al. 2012). Insufficient levels of physical activity have significant implications for the public health burden associated with non-communicable diseases. Non-communicable diseases are the leading cause of death worldwide. Globally, deaths attributable to these diseases are rising at an alarming rate. Low- and middle-income countries are particularly vulnerable to non-communicable disease related mortality and morbidity (Gostin et al. 2017). In 2004, it was projected that non-communicable disease related mortality in the South-East Asian region would increase by approximately 60% by 2030 (WHO 2011). In 2008, non-communicable diseases accounted for an estimated 55% of total deaths in this region (WHO 2011), and is likely to exceed 75% by 2030 (Narain et al. 2011). Though currently there are no overall regional data available, non-communicable disease related morbidity shows a steady increase in the South Asian countries (WHO 2011). Given the considerable increase in the burden of non-communicable disease in South Asian countries, and the protective role of physical activity against non-communicable diseases (Swift et al. 2016), it is imperative to better understand the physical activity profile of people living in this region.

Young adulthood, from age 18 to 24 years (Jekielek & Brown 2005), is the transition from adolescence, and an important phase of life (Gordon-Larsen et al. 2004). It involves significant life events; young adults may move away from home gaining full residential independence, commence work or tertiary education, and have more freedom in making lifestyle choices (Hogan 1978; Jekielek & Brown 2005). During this transition, young adults may adopt unhealthy lifestyle choices and engage in low levels of physical activity (Kwan et al. 2012). Though physical activity participation has been observed to decline across most of the lifespan, late adolescence and young adulthood years can have the most significant decrease in physical activity (Molina-Garcia et al. 2015; Simons et al. 2015). Physical inactivity during young adulthood can increase the risk for non-communicable diseases later in life (Hallal et al. 2006). Regular physical activity lowers cardio-metabolic risk factors of non-communicable diseases (Jakicic et al. 2015), reduces weight gain and increases the likelihood of weight loss and weight maintenance during young adulthood (Gordon-Larsen et al. 2009). Young adults engaging in regular physical activity have been reported to have higher self-esteem, a more positive body image and more positive health perceptions than their inactive counterparts (Korn et al. 2013). It has also been observed that young adults participating in high levels of physical activity have significantly lower levels of anxiety and depression (Tyson et al. 2010), and better mental health and satisfaction with life than inactive young adults (Rangul et al. 2012). Thus, physical activity provides immediate benefits for young adults such as improved psychological well-being and cognitive performance (Hogan et al. 2013).

Young adults' physical activity behaviour has predominantly been studied in high-income countries, and little is known about low- and middle-income countries. Available evidence, mostly from university students, suggests that the prevalence of physical inactivity in young adults in low- and middle-income countries is higher (44%) than in high-income countries (39%) (Pengpid et al. 2015). The few studies in Asian countries have reported the prevalence of inactivity among young adults to be 41% in Malaysia (Mohammed et al. 2014), 50% in Taiwan, 52% in South Korea, 71% in China and 75% in Japan (Frerichs et al. 2014). Although some physical activity data for Bangladesh are available for adults aged ≥25 years (Mohan et al. 2016; Pengpid et al. 2015), no data are available for young adults. Bangladesh is a South Asian country, and is ranked as the ninth most populated country in the world with a population density of 1,298 people per square kilometre as of July 2015 (CIA 2016). Given the established relationships between inactivity and non-communicable diseases (Riley et al. 2016), and the significant increase

in non-communicable diseases in Bangladesh in recent years (Chowdhury et al. 2016), it is crucial to collect physical activity prevalence data from Bangladeshi young adults.

Available evidence suggests that males are more active than females in low- and middle-income countries (Haase et al. 2004; Mohammed et al. 2014; Pengpid et al. 2015) as well as in Asian countries (Frerichs et al. 2014; Mohammed et al. 2014). However, there is little evidence for physical activity variation by other socio-demographic factors for young adults in this region. Some research in low- and middle-income and Asian countries has found physical activity levels decrease with age (Pengpid et al. 2015) and family income in this population group (Mohammed et al. 2014). To our knowledge, no study has offered a comprehensive overview of the sociodemographic patterns of physical activity participation of young adults in Bangladesh.

Hence, the present study aimed to assess the prevalence of participation of physical activity in young adults in Bangladesh, and explore differences by age, gender and family income. This information can inform interventions to increase opportunities for and engagement in physical activity of Bangladeshi young adults residing in the metropolitan areas of the country.

4.1.3 Methods

4.1.3.1 Study participants

This cross-sectional study with a self-administered survey was conducted during September-November 2015 in a convenience sample of young adults aged 18-24 years from six purposively selected universities (three public and three private) in Dhaka City, the capital of Bangladesh. In order to estimate the prevalence of young adults' physical activity with a 5% margin of error and 95% confidence interval, it was determined that this study needed at least 345 participants to achieve a power of 80% with the proportion of physically active students as 66% from an earlier study (Khan et al. 2017). From a list of 49 public/private universities, which offer undergraduate programs in Dhaka (University Grants Comission of Bangladesh n.d.), eight were chosen based on their size, diversity of students, convenience, and connection with the primary author. Of the eight invited to participate in this study, six universities (public = three and private = three) agreed. After obtaining approvals from the university authority, the principal investigator (first author) consulted with the institution nominated representatives (e.g., class lecturer) for a suitable

time to access the students during class time. The principal investigator explained the context of the study emphasising the voluntary nature of study participation, and then verbally invited the students to participate. Participants were recruited based on the following inclusion criteria: (1) undergraduate student, (2) aged 18 to 24 years, and (3) permanent residents of Bangladesh. Written informed consent was obtained from all participants. In Bangladesh, the medium of instruction is English at university undergraduate level. Thus, the written survey was completed in English: this took approximately 40-45 minutes.

4.1.3.2 Physical activity assessment

The Global Physical Activity Questionnaire (GPAQ) was developed by the WHO for population surveillance of physical activity in low- and middle-income countries (Armstrong & Bull 2006; Bull et al. 2009) and has been used in more than 100 countries through the STEPwise Approach to Non-communicable Disease Risk-Factor Surveillance (STEPS) program (Bull et al. 2009). Reliability and validity of the GPAQ has been assessed among adults aged ≥18 years in nine countries, including Bangladesh (Armstrong & Bull 2006; Bull et al. 2009), and found to have reproducible data and a 'moderate' to 'strong' positive correlation with the International Physical Activity Questionnaire (IPAQ). The current study used the GPAQ self-administered version, which is a relatively inexpensive method with comparable reliability and validity to the interview administration (Chu et al. 2015).

The GPAQ consists of 15 items on physical activity in three domains: work, commuting (travel to and from places) and during leisure time in a typical week (Bull et al. 2009). Items ask about moderate- and vigorous- intensity for the work and leisure domains and moderate-intensity activity for the transport domain (walking or bicycling). Moderate-intensity activities are defined as '*activities that require moderate physical effort and cause small increases in breathing or heart rate*'. Vigorous-intensity physical activities are defined as '*activities that require hard physical effort and cause large increases in breathing or heart rate*' (Bull et al. 2009). The questionnaire contained a number of visual illustrations with examples of different physical activities to explain the concept of moderate- and vigorous-intensity physical activity. For each domain, the participants were asked about the number of days physical activity was done in a typical week, and the hours/minutes spent doing such activities in a typical day.

The survey data were cleaned based on the GPAQ protocol (World Health Organization 2012). The following criteria were used to identify invalid responses:

i) if the value for activity was more than 16 hours/day in any of the physical activity sub-domains (vigorous-intensity work, moderate-intensity work, transport, vigorous-intensity leisure, or moderate-intensity leisure activity;
ii) improbable response such as activity reported for more than 7 days in a week;
iii) inconsistency in answering (e.g., transport activity was done 0 days in a week, but reported >0 minutes in the hour column) (World Health Organization 2012).

Consistent with the GPAQ data analysis guideline, all activity data were converted to minutes and were multiplied by the corresponding number of days (World Health Organization 2012). Vigorous activity minutes were weighted by two given the higher intensity than moderate activity (World Health Organization 2012). The time spent in vigorous activity (weighted) and moderate activity minutes were summed to obtain a measure of the total minutes/week spent doing moderate-to-vigorous physical activity (MVPA). Participants were then categorised as meeting the WHO recommendations or not, using the criterion of $\geq$150 minutes/week of MVPA (World Health Organization 2012).

Additional items were used to assess participation in specific types of physical activity. Participants were asked to report total time spent walking for recreation, exercise, or to get to or from places during a typical weekday and weekend day. Participants also indicated the frequency of engaging in each of 18 specific types of leisure-time physical activity (such as jogging/running, cricket, football, swimming/water exercise, gym, and yoga) with response options of daily, 2-3 times a week, at least once a week, and none.

4.1.3.3 Other measures

Participants also completed survey items to assess: age, gender, marital status, height and weight, university type, year of study, parents' educational qualification, and monthly gross household income. Due to a relatively narrow range (18-24 years), age was grouped into two categories: 18-20 and 21-24 years. Body mass index (BMI) was computed from self-reported height and weight and then grouped into one of three BMI categories based on criteria from the WHO: normal (<18.50 kg/m^2); underweight (18.50-24.99 kg/m^2) and overweight (≥25.00 kg/m^2) (World Health Organization n.d.-b). Monthly gross household income was used as a proxy socio-economic status indicator as done elsewhere (Pengpid

& Peltzer 2013) and categorised into one of four groups (≤20,000 Bangladeshi currency-BDT; 20,001-40,000 BDT; 40,001-70,000 BDT and >70,000 BDT).

A draft version of the questionnaire was piloted in a small convenience sample of undergraduate students of a university based in Dhaka City, Bangladesh (n=30, male=15, female=15). The aim of this pilot was to evaluate the feasibility of administering the questionnaire. Feedback from the pilot participants indicated that the questionnaire could be easily understood and answered.

4.1.3.4 Statistical analyses

The characteristics of the participants were summarised using descriptive statistics. Due to non-normal distribution of physical activity data, MVPA minutes/week were summarised using the median with interquartile ranges. Differences between physical activity medians by gender were analysed using non-parametric equality-of-medians test. The prevalence of meeting the WHO MVPA recommendations, and frequency of participation in different types of leisure-time physical activity were examined for possible gender differences and are reported as percentages with 95% confidence intervals for males and females separately. Using Chi-square test and Fisher's exact test, physical activity prevalence was further examined for possible age and income differences. This was done separately for males and females, as physical activity prevalence is likely to differ by gender (Pengpid et al. 2015; Sreeramareddy et al. 2012). Statistical significance was set at 5%. Data were analysed using STATA version 13 (StataCorp LP., College Station, Texas).

4.1.4 Results

4.1.4.1 Study participants

A total of 628 students were invited to participate in the study, and 575 completed the questionnaire (response rate 91.6%). Two respondents were excluded as they provided improbable or out of range data. As a result the analytical sample of the study consisted of 573 students with 45% female and an average age of 20.7 years (SD=1.35). Participants were predominantly single (94%), with the majority living with their parents (47%). Details on the socio-demographic characteristics of the study participants are presented in Table 4.1.1.

Table 4.1. 1: Characteristics of the participating young adults in Dhaka City, Bangladesh (n=573)

Characteristics		n¥	%
Age (years)			
	18-20	262	45.7
	21-24	311	54.3
Gender			
	Male	313	54.6
	Female	260	45.4
Marital status			
	Single	538	93.9
	Married or others (e.g., de facto, divorced, separated)	35	6.1
BMI			
	Normal range	353	61.7
	Underweight	139	24.3
	Overweight	80	14.0
University type			
	Public	277	(48.3)
	Private	296	(51.7)
Year of study			
	First year	184	32.1
	Second year	223	38.9
	Third year	166	29.0
Mother's educational qualification			
	Primary or equivalent	111	19.4
	Secondary (or equivalent)	147	25.7
	Higher secondary (or equivalent)	125	21.9
	Tertiary (or equivalent)	188	32.9
Father's educational qualification			
	Primary or equivalent	53	9.3
	Secondary (or equivalent)	64	11.2
	Higher secondary (or equivalent)	102	17.9
	Tertiary (or equivalent)	352	61.7
Monthly gross family income (in BDT)*			
	≤20,000	115	20.3
	20,001-40,000	162	28.6
	40,001-70,000	172	30.4
	>70,000	117	20.7

¥Total for each variable may not be equal to n=573 due to missing values* BDT = Bangladeshi Taka (local currency); 1 USD = 80.63 BDT as of 27 June 2017

4.1.4.2 Physical activity participation

Of the 573 participants, 17% (95% CI: 14-21%) met MVPA recommendations to do ≥150 minutes/week with significantly (p<.0001) more males [27% (22-32%)] than females [6% (4-10%)] meeting the recommendations.

Although more participants in the older group met MVPA recommendations, age was not significantly associated with meeting the recommendations (Table 4.1.2). Among males, 23% of those aged 18-20 years, and 30% of those aged 21-24 years met MVPA recommendations (p=.24). The proportions of females meeting the recommendations were 6% of those aged 18-20 and 7% of those aged 21-24 years (p=.65).

The proportion of participants meeting MVPA recommendations across the four income groups ranged from 14% to 22% with no statistically significant differences (p=.20). The proportion of participants meeting recommendations tended to be higher in the lower two income groups than the two higher income groups. The proportion of males meeting the MVPA recommendations ranged from 21% to 33% across the four income groups without any significant linear trend (p=.33). The proportion of females meeting the recommendations increased with increasing family income, though there was no statistically significant association (4% to 7%, p=.99) (Table 4.1.2).

Table 4.1. 2: Percentages (95% CIs) of male and female young adults in Dhaka City, Bangladesh meeting the WHO physical activity recommendations by age group and family income

Variable		Male			Female			Overall		
		% active	95% CI	*p*-value	% active	95% CI	*p*-value	% active	95% CI	*p*-value
Age (years)										
	18-20	23.1	16.3-31.2	.24[a]	5.5	2.2-10.9	.65[a]	14.5	10.5-19.4	.11[a]
	21-24	29.5	22.5-36.3		6.8	3.2-12.5		19.6	15.3-24.5	
Monthly family income										
	≤20,000	25.0	16.4-35.4	.33[a]	3.7	0.1-1.9	.99[b]	20.0	13.1-28.5	.20[a]
	20,001-40,000	33.3	23.9-43.9		5.8	1.6-14.2		21.6	15.5-28.7	
	40,001-70,000	21.4	13.2-31.7		6.8	2.5-14.3		14.0	9.1-20.0	
	>70,000	26.7	14.6-41.9		6.9	2.3-15.5		14.5	8.7-22.2	

[a] based on Chi-square test, [b] based on Fisher's exact test, CI=confidence interval
p<.05 was considered to be statistically significant

4.1.4.3 Participation in different domains of physical activities

Median time spent in total MVPA was 100 minutes/week (IQR: 60, 130) with males spending significantly more time [120 minutes/week (IQR: 80, 190)] than females [90 minutes/week (IQR: 50, 120)] (p<.0001). Although there was a trend for males to spend more time than females in each of work, commuting and leisure-time physical activity, this difference was statistically significant only for leisure (Figure 4.1.1). One-third (33%) of the participants (male: 30%, female: 37%) reported some form of work-related physical activity. Of these, the median time was 45 minutes/week (IQR: 30, 50) for males and 40 minutes/week (IQR: 15, 50) for females. Just over half of the participants (overall 53%, male 58% vs. female 47%) reported bicycling or walking for transport with a median of 90 minutes/week (IQR: 60, 135) for males and 80 minutes/week (IQR: 20, 120) for females. Half of the participants (overall 51%, male 64% vs. female 35%) engaged in leisure-time physical activity, with significantly more time among males [100 minutes/week (IQR: 60, 180)] than females [80 minutes/week (IQR: 60, 120)] (*p*=.03).

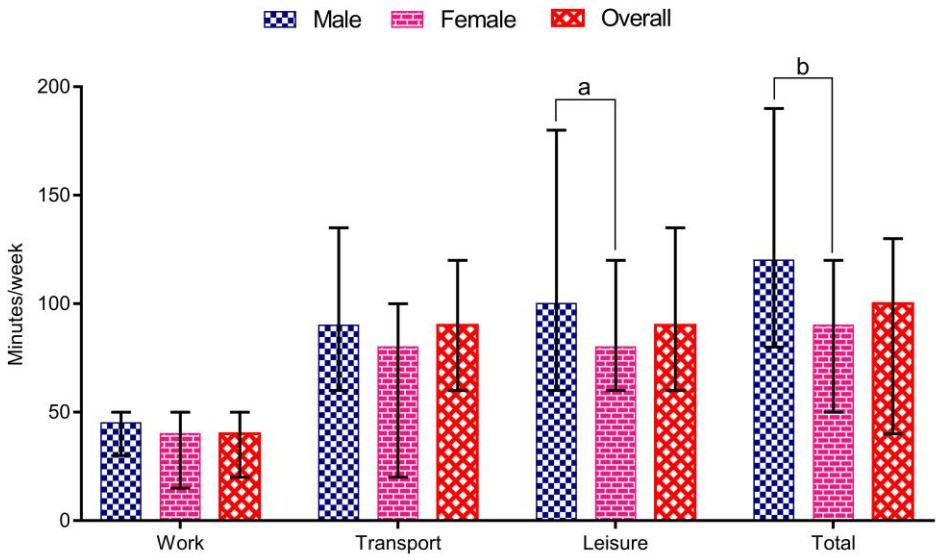

Figure 4.1. 1: Distribution of physical activity (median minutes/week) in young adults in Dhaka City, Bangladesh by gender

[a] Significant at *p*<0.05; [b] Significant at *p*<.0001; Error bars represent interquartile ranges
Work domain represents 190 participants who reported doing at least 10 minute bouts of work-related physical activity; male=94, female=96
Transport domain represents 305 participants who reported doing using at least 10 minute bouts of active transport; male=183, female=122
Leisure domain represents 291 participants who reported doing at least 10 minute bouts of recreational physical activity; male=199, female=92
Total physical activity represents the overall survey population; male=313, female=260

4.1.4.4 Time spent in walking

Median duration of walking did not differ significantly between males and females. During a typical weekday, the median time spent walking was 30 minutes (IQR: 30, 60) with slightly longer times among males [40 minutes (IQR: 30, 60)] than females [30 minutes (30, 60)]. Median walking time during a typical weekend day was 30 minutes (IQR: 20, 50) with a median of 30 minutes for both males (IQR: 30, 60) and females (15, 40).

4.1.4.5 Types of leisure-time physical activities

Figure 4.1.2 illustrates the top 10 types of leisure-time physical activity (excluding walking). Jogging/running was the most common type of leisure-time physical activity for the entire sample. Overall, 15.7% (95% CI: 12.8%-19.0%) participants reported jogging/running at least once a week, with 19.5% (15.3%-24.3%) of males and 11.2% (7.6%-15.6%) of females. Males participated more frequently in team sports, such as cricket, football etc. Cricket was the second most frequently reported leisure-time physical activity for males [16.3% (12.4%-20.9%)]. Among males, 12.5% (9.0%-16.6%) did football at least once a week, with no females playing football. More than one in ten [13.1% (9.6-17.4%)] males reported going to a gym at least once a week. Apart from jogging/running, females reported participating in indoor physical activities, such as yoga [6.2% (3.6%-9.8%)] and exercise such as using a stair climber and treadmill [2.7% (1.1%-5.5%)], and playing badminton [2.7% (1.1%-5.5%)].

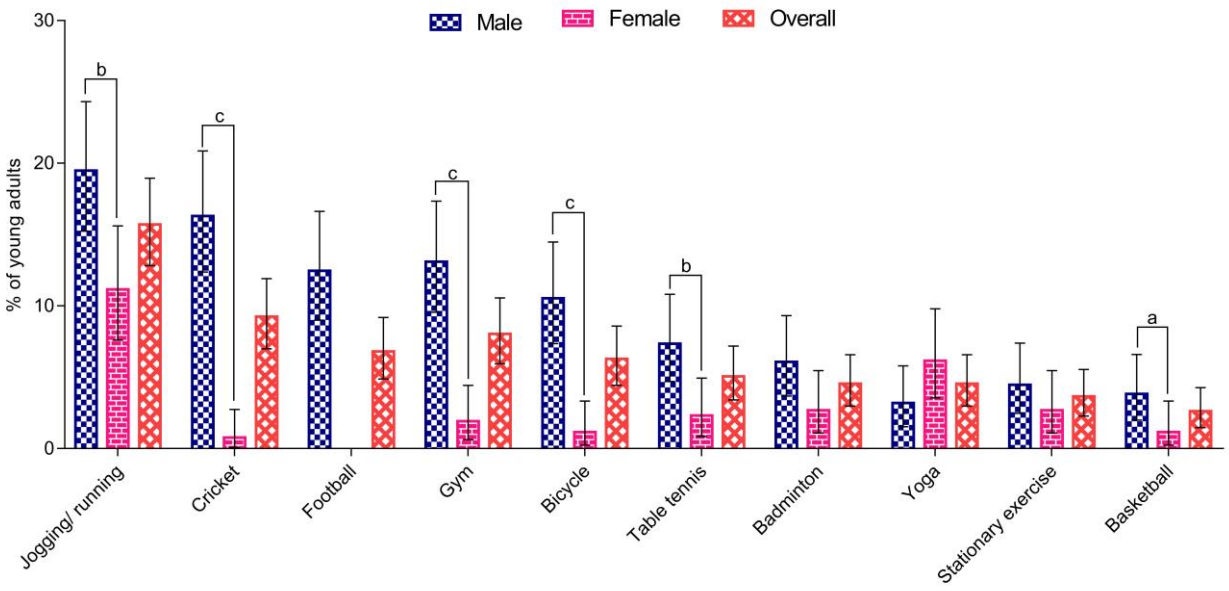

Figure 4.1. 2: Young adults' participation (percentages with 95% CIs) in different leisure time physical activities* by gender, Dhaka City, Bangladesh

* Selected top 10 leisure-time physical activities only
[a] Significant at p<.05
[b] Significant at p<.01
[c] Significant at p<.0001
Error bars represent 95%CI
CI=confidence interval

4.1.5 Discussion

Physical inactivity may negatively affect current physical and psychosocial health of young adults, and has long-term health consequences for non-communicable diseases. The present study found that four out of five young adults in Dhaka City, Bangladesh did not meet the WHO recommendations of at least 150 minutes per week of MVPA with more females (94%) than males (73%) not meeting recommendations. The percentage of participants not meeting physical activity recommendations in our study was higher than in previous studies with other age groups in Bangladesh using the same survey instrument (GPAQ). Those studies found that 27% to 52% of the participants aged ≥25 years did not meet the recommendations (Mohan et al. 2016; Moniruzzaman et al. 2017; Moniruzzaman et al. 2016; Zaman et al. 2015).

In our study, females were less active than males, which is consistent with previous studies across a range of countries including low- and middle-income and South Asian countries (Haase et al. 2004; Pengpid et al. 2015; Yahia et al. 2015). An earlier multi-country study found a significant gender difference (favouring males) in physical activity in

young adults regardless of the country status (Haase et al. 2004). In a recent study, a similar trend was observed in three South Asian Countries- Bangladesh, India and Pakistan (Pengpid et al. 2015). This gender difference in physical activity may reflect the social norms and gender roles that are common in Bangladeshi culture. In Bangladesh, females tend to have restricted outdoor engagement in recreational and social activities that often starts from puberty (UNICEF 2010). Socio-cultural customs in Bangladeshi society can separate males and females into two different worlds (Goetz 2013). While males can go outside, socialise and take part in outdoor activities such as cricket or football or cycling, females are often confined to domestic chores and not allowed to go outside freely (Goetz 2013; Islam 2013). Females are often restricted from exposure to non-family males and participating in team sports due to social taboo (Goetz 2013). Parents in Bangladesh may impose restrictions on female adolescents due to safety concerns (Gulati et al. 2014). For example, a study in Dhaka reported that 76% of female adolescents aged 14 to 16 years had experienced eve teasing (sexual/street harassment) (Airin et al. 2015). Thus, parents are likely to restrict or discourage their daughters from outdoor activities such as recreational walking or bicycling. It has been argued that gender differences in physical activity participation might also reflect gender differences in preferences for activities, with females preferring more passive social activities and males preferring more physically demanding pursuits (Lee & Trost 2006).

The clear gender difference in amount and types of physical activity observed in this study is crucial for physical activity promotion and policy implementation in the country. While promoting physical activity is important for all, female young adults are a priority group. More research is needed, therefore, to understand the factors that might positively and negatively influence physical activity participation of female young adults. Social factors such as family support; cognitive factors like enjoyment of physical activity and self-efficacy; and environmental factors such as perceived safety, availability, cost and access to physical activity facilities, have previously been identified as particularly important for physical activity of female young adults (Keating et al. 2005).

According to the current study, work-related physical activity contributed the least to total MVPA for both males and females. This is understandable as the participants were university students and therefore unlikely to engage in physically demanding occupations. In Bangladesh, some undergraduate students may work by providing private tuition, which requires no manual labour. A third of the participants in this study reported doing some amount of work-related physical activity with a higher rate of participation for females

(36%) than males (30%). This might reflect involvement in household activities, such as cleaning and home maintenance, cooking and shopping, which has been previously identified as more common among females than males in other low- and middle-income countries (UN 2010). In Bangladeshi family culture, women often are responsible for taking care of the children and other family members, preparing the meals, and doing other domestic tasks. Although the participants in this study were predominantly single (94%) and therefore perhaps free from family responsibilities, they may still do domestic activities if living with friends/classmates or alone. More research is needed to better understand how domestic activities contribute to physical activity of Bangladeshi young adults, in particular young women.

The current study indicated that just over half of the participants (male 58%, female 47%) reported bicycling or walking for transport. Several social and environmental factors might limit active commuting in Bangladesh. Rickshaws, a human-peddled small vehicle, are readily available and accessible to shuttle small distances rather than walking/bicycling. Lack of safe footpaths for walking and pathways for bicycling may be environmental barriers. Young females are vulnerable to crime while travelling and so are more likely to avoid walking (Shumi et al. 2015). In the metropolitan areas, such as in Dhaka, the streets are often not well lit at night and roads are highly congested with heavy traffic. Moreover, the social structure in Bangladesh does not support females bicycling to or from work as this is not a culturally acceptable norm. Transport-related physical activity could be promoted by building safe pathways for walking and cycling, ensuring the streets are well lit during night and thus improving perceived safety.

Other research has indicated that males prefer more physically demanding physical activity like team sports, and females tend to participate in physical activity such as walking, dance, aerobics and yoga (Keating et al. 2005). This is consistent with the findings of our study, where significantly more males engaged in outdoor leisure-time physical activity and team sports than females. Females more commonly reported doing yoga and indoor physical activity than males. However, female participation in jogging/running was comparable to the males, which seems contradictory. Other research however, has also indicated that this is often an individual activity preferred by females (Keating et al. 2005).

The current study found no statistically significant association between age and physical activity participation, which is consistent with the findings of a recent study in

Malaysia that used a similar age group (Mohammed et al. 2014). However, previous studies in low- and middle-income countries suggest an inverse relationship between age and physical activity in young adults (Pengpid & Peltzer 2013; Pengpid et al. 2015). Those studies, however, used a more aged varied sample, including adolescents aged 16 to 18 years, than the current study. It has previously been suggested that the greatest decline in physical activity occurs during the adolescent period (age 13-18 years) and slows during young adulthood (Sallis 2000). More research is needed to understand the relationship between age and physical activity in young adults in low- and middle-income countries.

Consistent with the findings of a previous study in South Africa (Pengpid & Peltzer 2013), family income was not associated with physical activity in this study. This may be because the participants in this study lived in areas where the logistics for physical activity did not differ by income. For example, the built environment for physical activity in Bangladesh does not vary greatly across residential areas, and available outdoor physical activity facilities, such as parks and playing fields are accessible to everyone. In this study there was, however, a trend for physical activity to be lower in the higher income groups. It is generally assumed that high-income enables access to paid physical activity facilities (e.g., gym, sports club) or home-based physical activity equipment (Konharn et al. 2014). However, as observed in adolescents from Thailand, which is another Asian country, it may be that high income enables more sedentary activities such as use of smartphones, computers, laptops, and video gaming facilities (Konharn et al. 2014). Income might be a relatively less important influence on physical activity of young adults in Bangladesh than individual factors such as attitudes and motivation.

The study had some limitations that warrant consideration. It used a non-random convenience sample of university students from a metropolitan city. As such, the results of this study do not represent all young adults of the country, and may have limited generalizability. The prevalence of physical activity presented in this paper was not adjusted; therefore, these results should be interpreted with caution. Physical activity was assessed using self-report, which is a common and convenient method in large population based studies; but vulnerable to social desirability and recall bias. Data were collected during the pre-examination period for some universities and so some students' physical activity could have been negatively influenced by their academic commitments. Other items used in the survey to assess total walking time for weekdays and weekend days and frequency of doing different leisure-time physical activities were not validated.

4.1.6 Conclusions

The present study found that four out of five young adults in Dhaka City, Bangladesh did not meet the WHO recommended level of physical activity for optimal health, with higher rates of insufficient activity among females than males. As physical inactivity is a well-documented risk factor for adverse health outcomes including non-communicable diseases, the findings of this study are alarming. Additional population based studies; preferably, longitudinal studies with representative samples from regional and metropolitan areas, and objective measurement of physical activity, are needed to confirm these findings and understand the factors associated with physical activity in Bangladeshi young adults, in particular among females.

4.2 Prevalence and patterns of sedentary behaviour

This manuscript is currently *under review*. This thesis contains the submitted version of the manuscript. The title (with authors) as follows:

Uddin R, Khan A, Burton NW. Are the young adults in Bangladesh sitting too much?

4.2.1 Abstract

The objective of this study was to estimate the level of sedentary behaviour (SB), and identify the common types of non-occupational leisure time sedentary activities in young adults in Dhaka, the capital city of Bangladesh. Data were from a convenience sample of 573 volunteer undergraduate students aged 18 to 24 years from six universities. Overall 45% of Bangladeshi young adults spent ≥8 hours/day in SB with significantly more females sedentary than males (52% vs. 39%, P=.001); computer and small screen use were the most common types of non-occupational SB for both males and females. Interventions are needed to reduce the high level of SB in Bangladeshi young adults, in particular targeting females and recreational screen time.

4.2.2 Introduction

Young adulthood is a key transition of life when individuals might adopt risky health behaviours such as spending increased amount of time in watching television, playing video games and using computer (Gordon-Larsen et al. 2004; Matthews et al. 2008; McVeigh et al. 2016). Sedentary behaviour (SB) has been recognised as an important public health issue in the past decade (Hallal et al. 2012), due to its positive association with a number of chronic health conditions, such as cardio-metabolic disorders, obesity, stress and depression (Nanney et al. 2015; Wilmot et al. 2012). However, few studies have assessed SB in low-middle-income countries, and included young adults. The aim of this study was to assess the level of SB, and identify common type of non-occupational SB, in university-based young adults in Bangladesh.

4.2.3 Methods

This cross-sectional study was conducted during September-December 2015 using a convenience sample of 573 undergraduate students from six universities in Dhaka, Bangladesh. Inclusion criteria were: age 18-24 years and permanent residents. SB was assessed using the self-administered adapted version of the Global Physical Activity Questionnaire (GPAQ); this has comparable reliability and validity to the interview administered version (Chu et al. 2015). The GPAQ item asks about (waking) time (hours and minutes) spent sitting/reclining on a usual day (including at work, at home, travelling, and leisure with friends or alone). This was split to ask about a typical weekday and weekend day. Total SB (mins/day) was derived as:

$$\text{Daily sedentary time (mins)} = ([\text{Weekday time} \times 5] + [\text{Weekend time} \times 2])/2$$

Additional items asked about time spent in each of seven types of non-occupational sedentary activities on each of a usual weekday and weekend day; and sociodemographics.

We used a cut-off of ≥ 8 hours (480 min/day) to classify respondents as “highly sedentary”. Sitting ≥8 hours/day has been shown to significantly increase the risk of all-cause mortality (Van der Ploeg et al. 2012), and used in a recent report of SB in South-East Asian adults (Win et al. 2015).

Participant characteristics were summarised using descriptive statistics. The proportion of highly sedentary participants is reported with 95% confidence intervals. Given the skewness of the data, medians with interquartile ranges were used to summarise time spent in SB and specific non-occupational activities. The non-parametric equality-of-medians test was used to examine possible gender differences in median sedentary time. Using Chi-square test, the proportion of high SB was further examined for possible gender differences.

4.2.4. Results

Of the 628 students who were invited to participate, 575 completed the questionnaire (response rate 91.6%). Two respondents were excluded due to incomplete information on SB. Thus, the analytical sample consisted of 573 respondents: 55% was male and the average age was 20.7 years (SD=1.35).

Participants spent a median of 450 mins/day (IQR: 360, 540) in SB, with females spending significantly more time in SB [480 mins/day (375, 570] than males [420 mins/day (330, 510)] (P<.001). Females spent significantly more time in SB on a weekday [420 mins/day (360, 540)] than males [360 mins/day (300, 480)] (P<.0001). The median SB time on a weekend day was also significantly higher for females [492 mins/day (390, 600)] than males [480 mins/day (360, 600)] (P=.002). Both females and males tended to report more time in SB during weekend days than weekdays.

Overall 44.7% (95% CI: 40.6%-48.9%) of the participants were highly sedentary, with a significantly greater proportion of females than males [51.9% (45.7%-58.1%) vs. 38.7% (33.2%-44.3%), P=0.001). The proportion of highly sedentary participants was greater for a weekend day [overall: 38.5% (34.5%-42.6%)] than a weekday [overall: 61.3% (57.1%-65.3%)]. Significantly more females than males were highly sedentary both on weekdays [45.0% (38.8%-51.3%) vs. 33.0% (27.8%-38.5%), P=.003] and weekend days [68.1% (62.0%-73.7%) vs. 55.6% (49.9%-61.1%), P=.002].

Computer use for fun (e.g., browsing, computer games) was the most common type of SB; there was no statistically significant gender difference in computer time, but longer times during weekend days than weekdays. Time watching television was similar for males and females on a weekday, but significantly longer for females than males on a weekend day (P=.003). A significant gender difference was observed for two types of SB; time in

sitting-talking and talking on the phone was significantly longer for females than males on both weekend and week days (Table 4.2.1).

Table 4.2. 1: Median (IQR) time spent in non-occupational sedentary activities by young adults in Dhaka city, Bangladesh, 2015

Type of sedentary pursuit	**Weekday (mins/day)**			**Weekend day (mins/day)**		
	Male	Female	p-value*	Male	Female	p-value*
Watching TV, movie, DVD	60 (30, 120)	60 (30, 120)	.36	120 (80, 210)	180 (120, 240)	.003
Using smartphone, tablet, notebook for fun	120 (40, 180)	70 (30, 180)	.64	120 (60, 240)	120 (30, 240)	.68
Using computer for fun	150 (90, 240)	120 (60, 240)	.36	210 (120, 315)	210 (120, 360)	.90
Listening to music	60 (20, 120)	60 (20, 120)	.57	60 (20, 120)	60 (25, 150)	.36
Traveling by motorised vehicles	30 (0, 120)	43 (0, 120)	.33	0 (0, 60)	0 (0, 30)	<.0001
Sitting-talking	60 (10, 120)	90 (30, 135)	<.0001	60 (0, 120)	120 (30, 180)	<.0001
Talking on the phone	30 (15, 60)	48 (20, 90)	.03	30 (10, 90)	60 (15, 120)	.002

*Non-parametric equality-of-medians test

IQR=interquartile range

4.2.5 Discussion

This study is the first to report the level of SB in a large sample of young adults in Bangladesh. Our finding that 45% of young adults reported ≥8 hours/day in SB is consistent with a recent study in Singapore that used the same criterion and found 48% young adults as highly sedentary (Win et al. 2015). Consistent with studies in developed countries (Matthews et al. 2008; McVeigh et al. 2016), our study also suggests that young adults spend about half of their waking time in SB. Use of a computer, smart phone or tablet were the most common types of non-occupational SB, with no significant gender differences. Although gender has been suggested as a predictor of computer use, the evidence is indeterminate and not well understood in developing countries (Rhodes et al. 2012).

Females were more highly sedentary than males. Females spent significantly more time watching television during weekend days than males, and were similar to males for weekdays. A review of evidence from developed countries suggested no gender differences in time spent watching television (Rhodes et al. 2012), however a study in Taiwan among adults aged ≥40 years found longer times among females than males (Chang et al. 2008). Females also spent significantly more time than males in sitting-talking and telephone conversations during weekdays and weekend days. This is inconsistent with a review of research from developed countries suggesting no gender differences in these types of SB for adults aged ≥18 years (Rhodes et al. 2012). This discrepancy might reflect the socio-cultural and –economic differences between participants in our and others' studies. However, with no comparable SB data from the South Asian region, it is difficult to comment on how socio-cultural differences may influence young adults' SB.

4.2.6 Conclusions

In conclusion, university-based young adults in Bangladesh spend prolonged time in recreational screen-based entertainments, in particular on weekend days. Being at university requires students to attend lectures for a considerable amount of time, which typically involves prolonged sitting. Students may also spend more sedentary time at home because of their study related commitments such as preparing assignments and academic reading. Pragmatic strategies such as on-campus physical activity facilities (e.g., gym) and weekend day social sports participation may reduce prolonged SB of young university

students in Bangladesh. The high level of SB in Bangladeshi young adults calls for urgent interventions, in particular among young adult females.

Chapter 5: Correlates of physical activity, sedentary behaviour, and factors associated with changes in these behaviours

Uddin R, Burton NW, Khan A (2018) Perceived environmental barriers to physical activity in young adults in Dhaka City, Bangladesh—does gender matter? *International Health* **10**:40-46. doi:10.1093/inthealth/ihx057

Contributor	Statement of contribution (Chapter 5 – Section 5.1)
Riaz Uddin (Candidate)	Conception and design (50%); analysis and interpretation (50%); drafting and production (50%)
Nicola W Burton	Conception and design (25%); analysis and interpretation (20%); drafting and production (20%)
Asaduzzaman Khan	Conception and design (25%); analysis and interpretation (30%); drafting and production (30%)

Uddin R, Burton NW, Khan A. Correlates of physical activity in university-based young adults in Bangladesh: A one-year prospective study [*under review*]

Contributor	Statement of contribution (Chapter 5 – Section 5.2)
Riaz Uddin (Candidate)	Conception and design (50%); analysis and interpretation (50%); drafting and production (50%)
Nicola W Burton	Conception and design (25%); analysis and interpretation (20%); drafting and production (20%)
Asaduzzaman Khan	Conception and design (25%); analysis and interpretation (30%); drafting and production (30%)

Uddin R, Burton NW, Khan A. Correlates of sedentary behaviour in university-based young adults in Bangladesh: A one-year prospective study *[under review*]

Contributor	Statement of contribution (Chapter 5 – Section 5.3)
Riaz Uddin (Candidate)	Conception and design (50%); analysis and interpretation (50%); drafting and production (50%)
Nicola W Burton	Conception and design (25%); analysis and interpretation (20%); drafting and production (20%)
Asaduzzaman Khan	Conception and design (25%); analysis and interpretation (30%); drafting and production (30%)

Uddin R, Burton NW, Khan A. What factors are associated with changes in physical activity and sedentary behaviour over one year among university-based young adults? [*under review*]

Contributor	Statement of contribution (Chapter 5 – Section 5.4)
Riaz Uddin (Candidate)	Conception and design (50%); analysis and interpretation (50%); drafting and production (50%)
Nicola W Burton	Conception and design (25%); analysis and interpretation (20%); drafting and production (20%)
Asaduzzaman Khan	Conception and design (25%); analysis and interpretation (30%); drafting and production (30%)

Correlates of physical activity, sedentary behaviour, and factors associated with changes in these behaviours

The overarching theme of Chapter 5 is to present the correlates of physical activity (PA) and sedentary behaviour (SB), and factors associated with changes in PA and SB over one year among Bangladeshi young adults (*Objective 2*). This chapter has four sections and answers Research question 3-6; section 5.1 contains a *published* paper, and section 5.2-5.4 contains manuscripts *under review*. Using cross-sectional Wave 1 data, section 5.1 presents perceived environmental barriers to PA among the study participants (Research question 3). Using one-year prospective data (Wave 1 and Wave 2), section 5.3 and 5.4 present the correlates of PA (Research question 4) and SB (Research question 5), respectively. Section 5.4, using prospective data, presents the factors associated with changes in PA and SB over one-year among Bangladeshi young adults (Research question 6).

5.1 Perceived environmental barriers to physical activity

This paper has been published in the *International Health*.

This chapter contains the author version of the paper. The copyedited and published version can be found at: http://dx.doi.org/10.1093/inthealth/ihx057

5.1.1 Abstract

Background: Physical activity (PA) has demonstrated health benefits, but participation is low in many countries. Little is known about environmental barriers to PA among Asian young adults. The purpose of this study was to identify common perceived environmental barriers to PA in young adults in Dhaka, Bangladesh and to examine if these barriers differed by gender.

Methods: This was cross-sectional study with a self-administered survey and data collected from a convenience sample of 573 students aged 20.71±1.35 years (female: 45%) in Dhaka. Binary logistic regression analysis was used to examine the association between environmental barriers and gender, adjusting for potential confounders.

Results: Poor street lighting at night (62%) and lack of convenient places to do PA (56%) were the most frequently reported environmental barriers to PA. Females were more likely than males to identify lack of neighbourhood safety (OR: 4.65; 95% CI: 3.09-7.00), poor street lighting [2.82 (1.95-4.11)], lack of convenient places [2.04 (1.39-3.00)], unclean and untidy neighbourhood [1.84 (1.25-2.72)] and poor weather [1.61 (1.11-2.33)] as barriers to PA, after adjusting for a set of confounders.

Conclusions: Findings suggest that environmental barriers to PA are particularly salient to young females in urban Bangladesh. This study underscores the need for safe and convenient options for PA that are also female friendly.

5.1.2 Introduction

Physical activity (PA) is well-documented to promote health in all age groups (Lee et al. 2012). However, approximately 23% of the global population aged ≥18 years is insufficiently active (WHO n.d.). This has significant public health implications especially for major non-communicable diseases (NCD) such as cardiovascular disease and type 2 diabetes (Lee et al. 2012). An estimated 66%-80% of deaths caused by NCDs occur in low- and middle-income countries (LMIC) (Oyeyemi et al. 2011). As in many other LMICs, NCDs are a major public health issue in South Asia – which has one-fifth of the world's population (Misra et al. 2014). In 2015, there were 78 million adults aged 20-79 years with diabetes in South Asia, and this is expected to double by 2040 with an estimated 140 million cases (IDF 2015). The health expenditure due to diabetes in this region is expected to increase from 7.3 million US dollars in 2015 to 12.9 billion US dollars by 2040 (IDF 2015). One of the major contributory factors for the increased prevalence of diabetes and other cardiometabolic syndromes in South Asia is the increasing prevalence of physical inactivity, which has been attributed in part to rapid urbanisation, increased industrialisation, mechanisation in domestic and workplace activities, and increased use of motorised vehicles (Misra et al. 2014).

Insufficient PA during young adulthood can increase the risk for NCDs in later life (Hallal et al. 2006). During the transition from adolescence to early adulthood, young adults may have more freedom to make lifestyle choices, which can often result in unhealthy practices such as insufficient PA (Kwan et al. 2012). In addition to increased risk of future NCD, insufficiently active young adults are significantly less healthy than their active counterparts (Korn et al. 2013). Regular PA in young adulthood has a range of physical and psychosocial health benefits such as healthy weight, reduced depression and anxiety, and overall physical and psychological wellbeing (Korn et al. 2013; Rangul et al. 2012).

The environmental influences on PA are of particular interest as area-level intervention strategies could be more effective in promoting PA at the population level and more sustainable than interventions targeting individual or social factors (Sallis et al. 2012). Research from different countries suggests that PA in young adults is associated with various environmental influences. Perceived personal safety; low crime rate; traffic safety; aesthetics; and availability of sidewalks, recreational facilities, convenient places for PA and green space can positively influence PA participation (Abdullah et al. 2016;

Musaiger et al. 2014; Oyeyemi et al. 2011). Some research in LMICs has shown differences by gender (Jáuregui et al. 2016; Oyeyemi et al. 2011); suggesting that females might experience or perceive environmental barriers to PA differently from males (Jáuregui et al. 2016). An unsafe neighbourhood, perceived poor street lighting, lack of convenient places such as a large park within close proximity of residence is likely to affect females' PA more than males' (Jáuregui et al. 2016; Oyeyemi et al. 2011; Saquib et al. 2016; Shumi et al. 2015).

Most of the evidence related to the environment and PA are, however, from developed countries such as the USA, Canada and Australia, with only a few studies from LMICs (Bauman et al. 2012). There is little information about young adults' perceptions of the environment for PA in LMIC Asian countries (Bauman et al. 2012). This is important as the environment in LMICs is likely to differ from high-income countries. LMICs are often characterised by higher population density; more traffic congestion, road traffic accidents, and crime; and less green space and infrastructure than high-income countries (Nantulya & Reich 2002; WBB-Trust 2015).

The aim of this study was, therefore, to understand the perceived environmental barriers to PA in young adults in an LMIC in Asia. This study was conducted with university students in Dhaka City, Bangladesh and aimed to (a) identify the commonly reported environmental barriers to PA, and (b) examine whether perceived environmental barriers to PA differed by gender.

5.1.3 Methods

5.1.3.1 Study design

We conducted a cross-sectional survey with a sample of 573 undergraduate students aged 18-24 years from six purposively selected universities (three public, three private) in Dhaka City, Bangladesh. We used a self-administered survey to collect data during September-November 2015.

5.1.3.2 Participants

From a list of 49 public/private universities which offer undergraduate programs in Dhaka (University Grants Comission of Bangladesh n.d.), we identified a convenience sample of

eight to be invited to participate in this study. These universities were selected to include a mix of public and private institutions (for socioeconomic diversity); and based on their large size, diversity of study areas; geographical convenience, and connection with the authors. Six universities agreed to participate. After obtaining approvals from the university authority, the principal investigator [RU] consulted with the institution nominated representatives (class lecturer) for a suitable time to access the students during classes. The principal investigator attended classes and explained the study emphasising the voluntary nature of participation, and verbally invited the students to participate. Study participants were required to be: (i) an undergraduate student, (ii) aged 18 to 24 years, and (iii) a permanent resident of Bangladesh. We obtained written informed consent from all participants. As this study was with university students and English is the medium of instruction at university level in Bangladesh, we administered the survey in English. A small pilot study with the survey indicated that English language was not a barrier to understanding the survey. Participants completed the survey in approximately 40-45 minutes. We asked questions about lifestyle and wellbeing, perceived environmental barriers to PA and sociodemographics.

5.1.3.3 Measurements

5.1.3.3.1 Perceived environmental barriers to PA

The participant information sheet and front page of the survey described PA as body movement causing an increase in breathing and/or heart rate, and including activities such as exercise, sports, competitive or friendly games swimming, walking and cycling. This is consistent with the working definition of PA used by the World Health Organisation (WHO) (World Health Organization n.d.-c).

Considering the socio-demographics and cultural aspects of Bangladesh, we selected seven environmental barrier items from previous PA research with young adults in LMICs (Abdullah et al. 2016; Oyeyemi et al. 2011) and Asia (Musaiger et al. 2014), and in the general population in LMICs (Ariffin & Zahari 2013; Jáuregui et al. 2016; Oyeyemi et al. 2012). Items included: “The weather is often too bad to do physical activity”; “There are no convenient places (e.g., parks or open fields) nearby for physical activity”; “It is not safe to walk in my neighbourhood”; “My neighbourhood is not clean and tidy”; “The footpaths are not in good condition in my neighbourhood”; “There is heavy traffic in my neighbourhood”; and “Streets are not well lit during night in my neighbourhood”. Respondents indicated to what extent they agreed or disagreed with each statement using

response options of 1='strongly disagree', 2='disagree', 3='unsure', 4='agree' and 5='strongly agree'.

5.1.3.3.2 Other measures

Participants also completed survey items to assess: age, gender, height and weight, marital status, university type, enrolled program, year of study, parents' educational qualification, parents' current occupation/employment status, monthly gross household income, household composition, and housing type. We grouped age into two categories: 18-20 and 21-24 years due to a relatively narrow range. We computed body mass index (BMI) from self-reported height and weight and then grouped into three categories based on major cut-off points suggested by the WHO: normal range (18.50-24.99 kg/m^2); underweight (<18.50 kg/m^2) and overweight (≥25.00 kg/m^2) (World Health Organization n.d.-b). We used monthly gross household income as a proxy socio-economic status indicator and categorised it into four groups (≤20,000 Bangladeshi currency-BDT; 20,001-40,000 BDT; 40,001-70,000 BDT and >70,000 BDT).

We piloted a draft version of the questionnaire in a small sample of undergraduate students (n=30, male=15, female=15) from a university based in Dhaka City, Bangladesh to evaluate feasibility and acceptability. Participants in the pilot study provided qualitative feedback on the written instructions; and instances where the items were unclear, difficult to understand, irrelevant, socio-culturally inappropriate or misleading. Based on this qualitative feedback the questionnaire was revised and finalised.

5.1.3.4 Statistical analyses

We report participants' responses to each of the environmental barrier items as percentages by gender. To identify the most commonly reported environmental barriers to PA, we dichotomised responses into categories of agreement [4 or 5] and non-agreement [1, 2 or 3], and reported the proportion of participants' in agreement as a percentage. Using binary logistic regression analyses we examined whether perceived barriers varied by gender, adjusted for potential confounders. We considered the following potential sociodemographics as potential confounders: age, gender, BMI, marital status, parental education and employment/occupation status, monthly gross household income, household composition, housing type, university type, enrolled program, and year of study. We selected only those confounders which had univariate associations with the corresponding dependent variables (barrier item) at 10% level in the univariate analyses.

Before entering the selected variables in the regression model, we examined them for collinearity. The final multivariable models included gender and the other variables which were statistically significant. We present unadjusted and adjusted odd ratios (OR) with 95% CI for each item with statistical significance set at 5%.

5.1.4 Results

5.1.4.1 Study participants

Of those invited, 575 participants completed the questionnaire (response rate 92%). Due to incomplete data, we excluded two participants from analysis. Thus, the analytical sample for this study consisted of 573 participants; 45% were female and the average age was 20.7±1.35 years. About 60% of the participants reported that their father had tertiary education, while 16% of participants' fathers were farmers/ day labourers. The gross monthly family income of the study participants was comparable across the four income-groups with 20% in the lowest income quartile and 21% in the highest income quartile, which suggests a reasonable representation of different socio-economic classes among the study participants. Table 5.1.1 summarises sociodemographic characteristics of the participants.

Table 5.1. 1: Characteristics of the participating young adults in Dhaka, Bangladesh, 2015 (n=573)

Characteristics		n¥	%
Age (years)			
	18-20	262	45.7
	21-24	311	54.3
Gender			
	Male	313	54.6
	Female	260	45.4
Marital status			
	Single	538	93.9
	Married or others	35	6.1
BMI			
	<18.50 kg/m^2	139	24.3
	18.50-24.99 kg/m^2	353	61.7
	≥25.00 kg/m^2	80	14.0
University type			
	Public	277	48.3
	Private	296	51.7
Year of study			
	First year	184	32.1
	Second year	223	38.9
	Third year	166	29.0
Mother's educational qualification			
	Primary or equivalent	111	19.4
	Secondary (or equivalent)	147	25.7
	Higher secondary (or equivalent)	125	21.9
	Tertiary (or equivalent)	188	32.9
Father's educational qualification			
	Primary or equivalent	53	9.3
	Secondary (or equivalent)	64	11.2
	Higher secondary (or equivalent)	102	17.9
	Tertiary (or equivalent)	352	61.7
Mother's employment status			
	Working	119	20.8
	Not working	452	79.2
Father's occupation			
	Government/ public service	152	26.7
	Non-government/ private service	96	16.9
	Professional	50	8.8
	Self-employed/ business	178	31.3
	Farmer/ day labourer	93	16.3
Monthly gross family income (in BDT)*			
	≤20,000	115	20.3
	20,001-40,000	162	28.6
	40,001-70,000	172	30.4
	>70,000	117	20.7

¥ Total for each variable may not be equal to n=573 due to missing values
*BDT=Bangladeshi Taka (local currency); 10,000 BDT = 121.14 USD as of October 23, 2017

5.1.4.2 Common environmental barriers

Nearly two-third of the participants (62%) were in agreement (agree + strongly agree) with perceiving poor street lighting at night as an environmental barriers to PA. The next most common barriers were lack of convenient places for PA (56%) and poor condition of the footpaths (54%). Just under half of the participants agreed (agree + strongly agree) that heavy neighbourhood traffic (48%) was a barrier. Approximately one-third of participants agreed that lack of safety (36%) and unclean/untidy neighbourhood (33%) were environmental barriers to PA. Less than one-third (29%) of the participants agreed that poor weather was a barrier to PA. Figure 5.1.1 shows that more females than males agreed that poor street lighting (74% vs 51%), lack of convenient places for PA (65% vs 49%) and lack of safety (55% vs 20%) were barriers to PA.

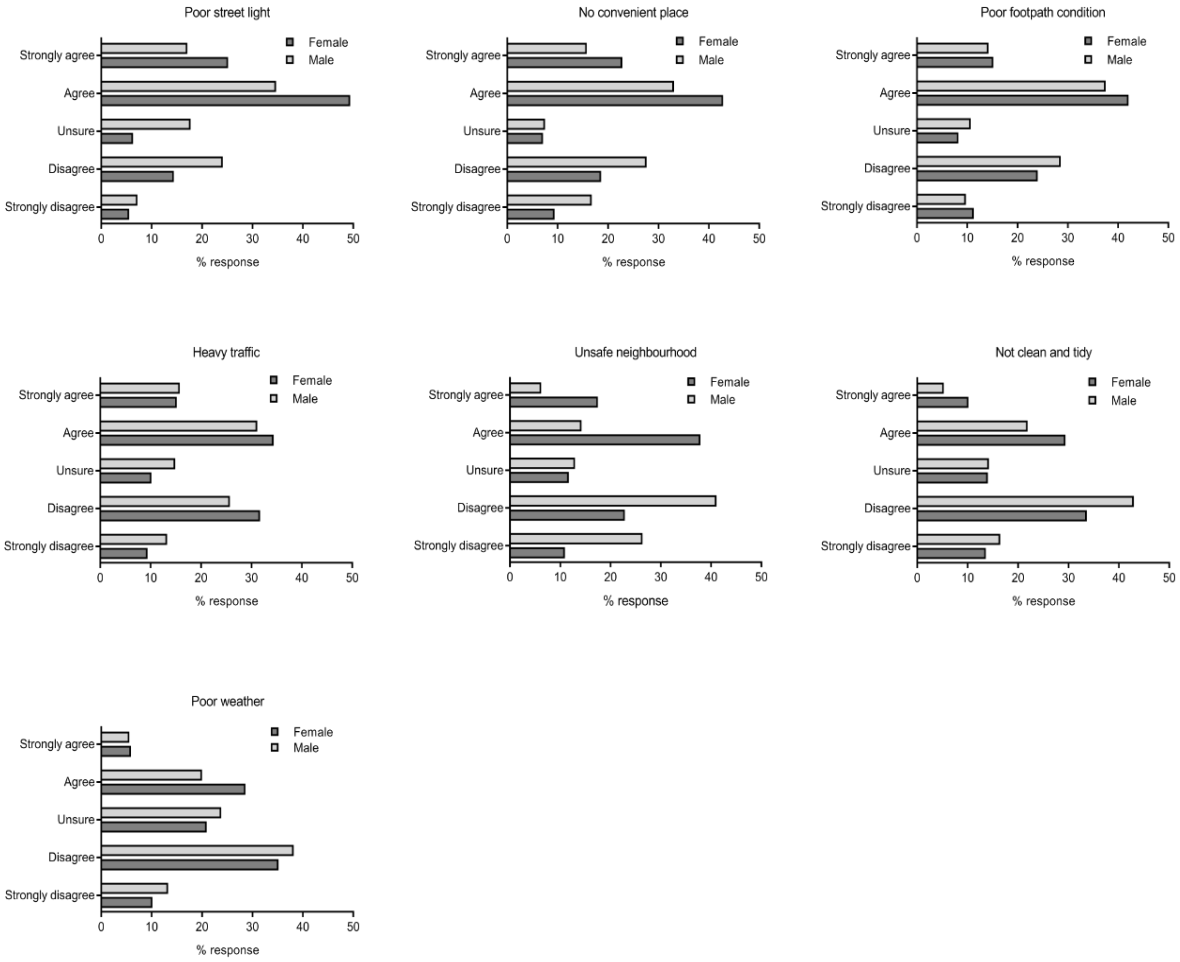

Figure 5.1. 1: Distribution of responses to barriers to physical activity across five of the response categories as percentage, by gender, Dhaka, Bangladesh, 2015

5.1.4.3 Gender differences in perception of environmental barriers

Females were over four times more likely than males to perceive lack of neighbourhood safety ($p<.001$) as a barrier to PA after adjusting for BMI, age group, mother's education, father's education, living arrangement, and housing type. As shown in Table 5.1.2, females were nearly three times more likely than males to perceive poor street lighting at night ($p<.001$) and two times more likely to perceive lack of convenient places for PA ($p<.001$) as a barrier to PA after adjusting for their corresponding set of confounders. Females were also significantly more likely than males to perceive lack of neighbourhood cleanliness/tidiness ($p=.002$) and poor weather ($p=.012$) as barriers to PA after adjusting for their corresponding set of confounders as listed in Table 5.1.2.

Table 5.1. 2: Logistic regression estimates of associations between perceived environmental barriers to physical activity and gender, adjusted for potential confounders, in young adults, Dhaka, Bangladesh, 2015

Perceived environmental barrier[#†]	Unadjusted OR for females (Ref: male)	95% CIs	Adjusted OR for females (Ref: male)	95% CIs	*p-value*
It is not safe to walk in my neighbourhood[a]	4.85	3.35 - 7.01	4.65	3.09 - 7.00	**<.001**
Streets are not well lit during night in my neighbourhood[b]	2.72	1.91 - 3.88	2.82	1.95 - 4.11	**<.001**
There are no convenient places nearby[c]	2.00	1.43 - 2.81	2.04	1.39 - 3.00	**<.001**
My neighbourhood is not clean and tidy[d]	1.76	1.24 - 2.50	1.84	1.25 - 2.72	**.002**
Weather is often too bad to do physical activity[e]	1.54	1.07 - 2.21	1.61	1.11 - 2.33	**.012**
The footpaths are not in good condition in my neighbourhood[f]	1.25	0.90 - 1.74	1.29	0.90 - 1.84	.165
There is heavy traffic in my neighbourhood[g]	1.11	0.80 - 1.54	1.09	0.77 - 1.53	.625

[#]Response to barriers were dichotomised as agreement (agree+strongly agree) and non-agreement (strongly disagree+disagree+unsure)
[†] Each model is adjusted for confounders having a univariate association with the corresponding perceived barrier items at p≤.1.
[a] Adjusted for BMI, age group, mother's education, father's education, living arrangement, and housing type
[b] Adjusted for mother's education and employment status
[c] Adjusted for age group, university type, father's education, monthly family income, living arrangement, and housing type
[d] Adjusted for university type, monthly family income, living arrangement, and housing type
[e] Adjusted for age group, university type, and living arrangement
[f] Adjusted for university type, mother's education, father's education, and living arrangement
[g] Adjusted for and father's education and housing type
CI=Confidence interval
Values in bold indicates a p value ≤.05

5.1.5 Discussion

This study identified common perceived environmental barriers to PA in an urban sample of young adults in Bangladesh. The findings are consistent with a growing body of literature exploring environmental barriers to PA in LMICs (Abdullah et al. 2016; Ariffin & Zahari 2013; Jáuregui et al. 2016; Oyeyemi et al. 2012; Oyeyemi et al. 2011). This study indicates that perceptions of environmental barriers to PA may differ by gender; with females more likely than males to report environmental barriers. Safety and convenience were particularly salient issues for young adult females.

Poor street lighting was the most commonly reported environmental barrier to PA, with females more likely to report this than males. Asian urban adults have previously reported sufficient street lighting as a positive influence on PA (Ariffin & Zahari 2013). Enough street lighting is very important from a safety perspective, as it is likely to increase visibility, help identification of roadway obstacles, minimise slip and trip hazards, and thus enable safe walking/cycling. Street lighting may also be important for travel to and from PA opportunities (e.g., sports, training, fitness centres) at night. People may perceive it unsafe to be in a street, which has poor lighting because of the possibility of being a victim of crime (e.g., mugging).

Consistent with a previous study in a sample of university students in Nigeria (Oyeyemi et al. 2011), we found that perceived neighbourhood safety was more salient to females than males. In Bangladesh, females tend to avoid walking (which could be for exercise or to get to and from PA), even in daylight, because they perceive themselves as vulnerable to crime (Shumi et al. 2015). As walking is the most common form of PA undertaken in neighbourhood streets and public open spaces (Foster & Giles-Corti 2008), ensuring females feel secure to walk in their neighbourhood is important. Neighbourhood safety may also impact on outdoor activities (e.g., sports) or use of public PA facilities e.g., parks. Improving neighbourhood safety is a multidisciplinary issue that involves infrastructure, local policing and participation of the local community.

More than half of the participants perceived that they did not have a convenient place nearby for PA. Consistent with a recent study in Bangladeshi adults (Saquib et al. 2016), we found more females than males reported the lack of convenient places as an environmental barrier to PA. This could include places such as parks or other open space suitable for walking or jogging, sports clubs, fitness centres and gyms. In LMICs, lack of

access to recreational facilities such as parks is one of the most consistently identified environmental barriers to PA (Bauman et al. 2012; Jáuregui et al. 2016). Parks are an important recreational setting (Kaczynski & Henderson 2008), and may offer facilities for PA and foster increased PA participation. Dhaka, as one of the most densely populated cities in the world, however, offers few green or public open spaces. According to the WHO, the city has a 0.052 square metres of green space per capita, well below the recommendation of nine square metres per capita set by the WHO (WBB-Trust 2015). Given the large population and limited space, it would be a major challenge for the policymakers to introduce more green space in the city. However, policymakers could consider other opportunities for convenient places to do PA e.g., improving the university PA infrastructure, offering free PA equipment for home use, and creating indoor PA facilities in local residential areas.

More than half of the participants reported the poor condition of footpaths as a barrier to PA, with no statistically significant gender differences. However, females were more likely than males to report lack of neighbourhood cleanliness or tidiness as barrier to PA. In general, the poor condition of walkways and local areas is likely to offer less aesthetically pleasant neighbourhoods, which can preclude people from walking and using local facilities for activity (Oyeyemi et al. 2011). Many footpaths in the city remain inaccessible mainly due to the dumping of construction materials, illegal motor vehicle parking, temporary shops, and street vendors (Efroymson & Hossain 2015). This may be particularly important for females who are more likely to do walking within the close proximity of their neighbourhood because of safety and convenience issues (Foster & Giles-Corti 2008).

Nearly half of the participants reported heavy traffic as an environmental barrier to PA, with no significant gender differences. Heavy traffic is a subjective perception, such as feeling unsafe crossing a road (SWOV 2012). Evidence related to unsafe traffic conditions (e.g., heavy traffic) and its relationship with PA is inconsistent in general population studies in LMICs (Oyeyemi et al. 2012; Oyeyemi et al. 2011). The roads in Dhaka city are often highly congested. Motorists are unlikely to obey traffic laws; they often do not share the road responsibly or follow lanes, drive on the wrong side of the road, and violate regulatory signs and traffic lights (Islam et al. 2016). Non-motorised vehicles used for public transport such as rickshaws share roads with motorised vehicles, even on highways, and are likely to contribute to traffic congestion in the city. The heavy traffic system in urban areas of Bangladesh, especially in Dhaka, may discourage people from walking or bicycling during

leisure time or for active commuting. Heavy traffic may also discourage people from travelling to PA opportunities (e.g., fitness centre, sports, training) because of the time, stress and inconvenience involved.

According to the most recent estimates, Dhaka is ranked as the densest city in the world with 44,100 people per square kilometre (Cox 2016). Given such a high population burden, traffic congestion may be unavoidable in the city. With existing resources, law-enforcement strategies are needed to ensure motorists obey traffic laws; and increase pedestrian/cyclist safety. Awareness campaigns using mass media such as television, social media, and print media can be useful to build awareness about road safety. Urban planners may consider road pricing and road space rationing (vehicle use rotation), introducing fees to enter heavy traffic areas, and car-free weekends to mitigate traffic congestion. Due to insufficient public transport in the city, there is a high demand of rickshaws among urban dwellers, which also contributes to traffic congestion. Measures such as increasing the number of buses on the road, and restricting rickshaws to local areas may be useful to address this issue. Separate bicycle lanes can be useful to improve cyclists' safety, but also may not be pragmatic with the existing urban infrastructure of Dhaka city. Most of the existing roads are not wide enough and in most of the places, the buildings are within close proximity of the roads, leaving little or no space for additional lanes for bicycles. However, for the suburbs around the city, which are going through an urban transformation, separate bicycle lanes could be included to promote active transport.

Poor weather had the lowest level of agreement in our study, with only one-third of participants perceiving it as a barrier. This is inconsistent with a study of environmental barriers to PA in university students in Kuwait (Musaiger et al. 2014). Bangladesh has a subtropical monsoon climate: Although there is seasonal rainfall, high temperature and humidity during summer in Bangladesh, the overall climate is significantly different from countries in the Arabian Gulf region, which are often characterised as having a long, hot and humid summer (Musaiger et al. 2014). However, consistent with the Kuwait study, we found that females were more likely than males to report poor weather as a barrier. Indoor (climate controlled) PA facilities may promote PA in young females in Bangladesh.

This is the first study to assess perceived environmental barriers to PA in a large sample of young adults in Dhaka, Bangladesh. The study had some limitations. The cross-sectional design does not allow determination of causality. We used a convenience

sample of university students from a large metropolitan city, which may not be generalisable to other young adults of the country. Self-reported questionnaires to measure environmental barriers may have been subject to bias and individual interpretation; e.g., although a student may live in a relatively quiet residential area, s/he may report neighbourhood traffic as very high. However self-report is a common means to understand these perceived barriers (Ding et al. 2013). This study did not report on PA level, and if perceived environmental barriers were actually (negatively) associated with actual PA participation. It is possible, for example, that those participants who were physically active reported more barriers as they may be more likely to experience them than those who are inactive. Therefore, future studies could use longitudinal assessment, include objective environment measurement, and examine links between reported barriers and PA participation. We assessed a limited number of environmental factors, and so cannot report on other potential environmental barriers such as poor street connectivity, lack of accessible bicycle paths, lack of accessible health clubs and unattended dogs. The potential barriers we assessed may not have been relevant to all types of PA, and may not have addressed all local specificities relevant to PA barriers.

5.1.6 Conclusions

We identified some specific environmental factors commonly perceived as barriers to PA by young adults in urban Bangladesh and found females reported more barriers than males. The main environmental barriers to PA were the lack of neighbourhood safety, poor street lighting at night and lack of convenient places nearby for PA. These issues may be particularly salient to females. This study underscores the need for local, safe and convenient PA opportunities for young adults in this area. Future research could focus on population-based studies including representative samples from regional and metropolitan areas to better understand how the environment may influence PA participation of young adults in Bangladesh.

5.2 Correlates of physical activity

This manuscript is currently *under review.* This thesis contains the submitted version of the manuscript. The title (with authors) as follows:

Uddin R, Burton NW, Khan A. Correlates of physical activity in university-based young adults in Bangladesh: A one-year prospective study.

5.2.1 Abstract

Objectives: To identify correlates of physical activity (PA) of university-based young adults in Bangladesh, using prospective data.

Methods: Data were from a one-year prospective study with two assessment points. During Wave 1, a convenience sample of 573 students (20.7±1.35 years; 45% female) completed a self-administered written survey on PA; and psychological, social, health and lifestyle, and sociodemographic factors. During Wave 2, retention rate was 69%. PA was assessed with the Global PA Questionnaire (GPAQ). Generalized Estimating Equations (GEE) was used to identify the correlates of PA, separately for females and males.

Results: Overall, 17% participants at Wave 1 and 23% at Wave 2 met the World Health Organization's (WHO) recommendations for PA (≥150 mins/week). A higher proportion of males than females met the recommendations at both waves (27% vs 6% and 34% vs 12% at Wave 1 and Wave 2, respectively). GEE modelling identified that PA efficacy and organised sports participation were positively associated with PA for both males and females. Increased age, outcome expectations, and life satisfaction were positively associated, and long sleep duration was negatively associated, with PA in female young adults. Psychological distress was negatively associated, with PA in young adult males.

Conclusions: Insufficient PA is very common among young adults in Bangladesh, with a higher prevalence among females than males. The individual-level correlates identified in this study can be used to promote PA in young adults in urban Bangladesh.

5.2.2 Introduction

Young adulthood, from age 18 to 24 years (Jekielek & Brown 2005), is a critical period of life (Gordon-Larsen et al. 2004). The transition from adolescence to adulthood involves crucial life events; many young adults may gain full residential independence, move away from the parental home, commence work or enrol in universities. During this transition, young adults are likely to have increased autonomy in making lifestyle choices (Hogan 1978; Jekielek & Brown 2005), which may include unhealthy behaviours such as insufficient physical activity (PA) (Gordon-Larsen et al. 2004; McVeigh et al. 2016). Insufficient PA may have concurrent and future health implications in young adults, e.g., increased risk for non-communicable diseases (NCD), cardio-metabolic risk factors such as increased weight gain, anxiety and depression, and lower self-esteem and cognitive performance (Gordon-Larsen et al. 2009; Hogan et al. 2013; Tyson et al. 2010). Further work is needed, therefore, to understand the factors associated with PA among young adults.

As a habitual and context-specific behaviour, it is essential to identify and understand the country, age and population-specific correlates of PA to develop evidence-based intervention strategies (Keating et al. 2005; Martins et al. 2017). Strategies to promote PA should target factors identified as significantly associated with PA in that age group and culture. Research in developed and developing countries suggest specific sociodemographic, psychological, social, and health and lifestyle correlates of young adults' PA (Kilpatrick et al. 2005; Mirzaei-Alavijeh et al. 2018; Pedisic et al. 2015; Rangul et al. 2012; Romaguera et al. 2011; Rovniak et al. 2002; Seo et al. 2009; Shuval et al. 2009; Towne et al. 2017; Yasunaga et al. 2014). University-based young adults' PA is positively associated with socio-demographic correlates such as male gender (Seo et al. 2009; Shuval et al. 2009), increased age (Romaguera et al. 2011), and high maternal education level (Romaguera et al. 2011). Psychological correlates positively associated with PA include PA efficacy (Mirzaei-Alavijeh et al. 2018; Rovniak et al. 2002; Shuval et al. 2009) and positive outcome expectations (Kilpatrick et al. 2005; Mirzaei-Alavijeh et al. 2018; Yasunaga et al. 2014). Perceived social support has consistently been reported as a correlate of PA among university-based young adults (Mirzaei-Alavijeh et al. 2018; Rovniak et al. 2002; Yasunaga et al. 2014). Being satisfied with life (Pedisic et al. 2015; Rangul et al. 2012), and having good psychosocial health and optimal sleep (Feng et al. 2014; Towne et al. 2017) have also been positively associated with young adults' PA.

A few studies have reported correlates of PA in Bangladeshi populations. A recent study with Bangladeshi adults aged 25-64 years found that being female, being a stay-at-home mother, higher education attainment (e.g., secondary or tertiary level) and high socio-economic status (e.g., being affluent) were negatively associated with PA (Moniruzzaman et al. 2017). A recent study with Bangladeshi adolescents aged 13-17 years reported that walking to school, having sports equipment at home were positively associated with PA in both boys and girls (Khan et al. 2017). In that study, participation in sports at school and mother's higher education level were postively associated with PA among adolescent girls, and having a working mother and playground at school were positively associated with PA among adolescent boys. However, in relation to young adults' PA, Bangladesh is one of the most under-studied countries and little is known about PA correlates for Bangladeshi young adults aged 18-24 years. This is of concern given that approximately one-fifth of the population are aged 15-24 years Bangladesh (United Nations 2016) and there is an increased prevalence of inactivity-related NCDs in young adults (Global Burden of Disease n.d.). The present study therefore aimed to identify socio-demographic, psychological, social, and health and lifestyle correlates of university-based young adults in Dhaka, Bangladesh, using one-year prospective data. This information is essential to help formulate PA promotion strategies among urban young adults in Bangladesh.

5.2.3 Methods

5.2.3.1 Ethics statement

Ethics approval was from The University of Queensland Behavioural and Social Sciences Ethical Review Committee, Australia. Each participating institution granted approval to conduct the survey on their premises. All the participants provided written informed consent at Wave 1 to participate in both survey waves.

5.2.3.2 Study design and population

Data are from a one-year prospective study with two-time points. Wave 1 data were collected during September to December 2015 and Wave 2 during October to November 2016. A convenience sample of first, second and third-year students aged 18 to 24 years were recruited from six (three public and three private) universities in Dhaka, the capital city of Bangladesh. The recruitment procedure has been described elsewhere (Uddin et al.

2017). A self-administered written survey was used to collect data. The survey included questions on PA and sedentary behaviour (SB), as well as psychological, social, health and lifestyle and sociodemographic factors potentially relevant to young adults' PA. Participants completed the survey in approximately 40-45 minutes during Wave 1. A sub-set of the Wave 1 survey, including items on PA, was used during Wave 2, which the participants completed in 15-20 minutes. The survey was in English. Field-testing with 30 undergraduate students (female 50%) at a university based in Dhaka city suggested no difficulties with understanding the instructions and completing the survey.

5.2.3.3 Outcome variable

PA was measured with the Global Physical Activity Questionnaire (GPAQ), a widely used reliable and valid self-reported tool developed by the World Health Organization (WHO) (Bull et al. 2009). In the current study, the self-administered version of the GPAQ was used (Chu et al. 2015). This method is relatively inexpensive with comparable reliability and validity to the original interview administered protocol (Chu et al. 2015). The respondents reported the number of days in a week, and the amount of time in a typical day of the week, spent doing each of moderate-intensity PA (MPA) and vigorous-intensity PA (VPA) for each of work and leisure; and MPA for walking or cycling for commuting. Consistent with the data analysis guidelines for the GPAQ, all activity data were converted to minutes and multiplied by the corresponding number of days (World Health Organization 2012). VPA minutes were weighted by two given the higher intensity than MPA (World Health Organization 2012). The time spent in VPA (weighted) and MPA were summed, to obtain total MVPA mins/week, which was used as a continuous outcome variable. For descriptive purposes, total MVPA mins/week was dichotomised as '*sufficient PA*' (>150 minutes/week) and '*insufficient PA*' (<150 minutes/week). This is consistent with the WHO's recommendations (World Health Organization 2012). Following the WHO GPAQ scoring protocol (World Health Organization 2012), four respondents (two each at Wave 1 and 2) were excluded from the analyses as they provided improbable or out of range data.

5.2.3.4 Explanatory variables

5.2.3.4.1 Other activity behaviours

Participants were asked to report if they currently participate in any organised sports at university or outside university facilities (yes/no). Participant's SB was assessed with

questions about total time spent sitting/reclining during waking hours of each of a typical weekday and weekend day using the same wording and response options of the GPAQ (Bull et al. 2009). Total daily sedentary time in minutes was computed as: (weekday sedentary time×5 + weekend day sedentary time×2)/7.

5.2.3.4.2 Psychological factors

Potential psychological correlates included PA efficacy, outcome expectations, and PA importance. PA efficacy was measured using a 4-point Likert scale with five items (Schwarzer & Renner 2009). The items asked about confidence to overcome barriers - such as having worries (or problems), feeling depressed, tensed, tired, and lack of time (too busy) - to persistently engage in PA. An exploratory factor analysis with varimax rotation offered a one-factor solution that accounted for 52% of the variance, with Cronbach's alpha being 0.85. Scores were summed to generate a total PA efficacy score (range: 5-20) with high scores representing high efficacy.

PA outcome expectations were assessed with a 5-point Likert scale with five items from the Benefits of Physical Activity Scale (Sallis et al. 1989), which asked about anticipated benefits of regular PA. An exploratory factor analysis with varimax rotation confirmed the unidimensionality of the five items examined with a one-factor solution that accounted for 56% of the variance, with Cronbach's alpha being 0.79. Scores were summed to generate an outcome expectations score ranging from 5 to 25 with high scores representing positive outcome expectations.

Perceived importance of PA was assessed using a single item. Participants responded to the question 'How important is physical activity in your life?' on a 6-point Likert-scale.

5.2.3.4.3 Social factors

Social support for PA was assessed with 10 items from the Social Support for Exercise Survey Scale (Sallis et al. 1987). An exploratory factor analysis with varimax rotation confirmed the unidimensionality of the 10 items examined with a one-factor solution accounting for 91% of the variance with Cronbach's alpha being 0.87. The item scores were summed to generate a total social support score (range: 6-36; one item was reverse scored) with high scores representing high level of social support for PA.

5.2.3.4.4 Health and lifestyle factors

Health and lifestyle factors assessed included psychological distress, physical and psychological conditions, general health, body mass index (BMI), sleep duration and quality, and other health behaviours. Participants completed the Kessler Psychological Distress – K6 scale with six items (Kessler et al. 2002). An exploratory factor analysis with varimax rotation confirmed the unidimensionality of the scale in this current population with a one-factor solution that accounted for 58% of the variance with Cronbach's alpha being 0.85. The item-scores were summed to generate a total distress score (range: 0-24), with a high score representing more distress.

Other items assessed frequency of specific physical (e.g., headache, muscular pain, stomach cramps) and psychological (e.g., depression, anxiety, sleep difficulties) conditions over the past 30 days. Participants rated their general health (perceived health) and indicated how satisfied they were with their life on a 10-point Likert scale.

Participants' BMI was computed from self-reported height and weight. Participants were asked to report time spent in sleep during each of a typical weekday and weekend day. Total sleep time per day was computed as: (weekday sleep time×5 + weekend day sleep time×2)/7, and categorised as healthy (6.5-8.5 hrs/day), short (<6.5 hrs/day) and long (>8.5 hrs/day) duration (Hale 2005). Other health items assessed cigarette smoking status and number of cigarettes smoked in a typical day (or week), and alcohol consumption. Participants were asked about consumption of non-alcoholic carbonated beverage e.g., Coke, Pepsi, excluding diet Coke or cola type soft drinks in the past seven days. Participants were also asked the number of days in the past seven days they had breakfast, they brought a homemade lunch to university, and the number of times they consumed some popular food items (e.g., fast food, fruits, vegetables). Dietary behaviour-related items were from a recent survey on PA among adolescents in Bangladesh (Khan et al. 2017).

5.2.3.4.5 Sociodemographic factors

Participants were asked to report their age in completed years, gender, marital status, and whether or not they had children. Participants were also asked to report monthly gross household income, enrolled university program, year of study, source of financial support for study, employment status and weekly time working (in case of paid part-time/full-time work). Survey items also asked about mother's and father's highest education attainment level and occupation type. Participants were asked to report their living arrangement (e.g.,

living alone, with parents) and their type of accommodation (e.g., non-university accommodation such as living in own house/flat, university accommodation/hall).

5.2.3.5 Statistical analyses

The proportions of young adults meeting the WHO PA recommendations were identified. These were used to describe the prevalence of PA over two assessment points. To identify correlates of PA, MVPA mins/week was used as a continuous variable. Due to non-normal distribution of level of MVPA, which were collected at two time points, Generalized Estimating Equations (GEE) with *gamma* distribution and *log* link under *exchangeable* correlation structure was used to identify the correlates. GEE, which is an extension of generalised linear model, is useful in studies with repeated measures, and is often used to analyse longitudinal as well as other correlated data. In this analysis, GEE took into account the non-independence of participants' MVPA mins/week nested within the two waves. In Bangladesh, young adult males and females can be considered as two different population groups in relation to participation in and opportunities for PA, which may be guided by socio-cultural customs and norms, and gender roles (Goetz 2013). Given this, separate models for females and males were constructed.

From a set of 27 explanatory variables, variables which had bivariate associations with the MVPA mins/week at a 20% significance level [as recommended elsewhere (Maldonado & Greenland 1993)] were identified and examined for collinearity. In the bivariate analyses, age, father's education and occupation, mother's employment status, BMI, organised sports participation, SB, sleep duration, psychological distress, PA efficacy, PA outcome expectations, social support, life satisfaction, and each of consumption of fresh fruits, vegetables and carbonated beverages were associated with female young adults' MVPA mins/week at 20% significance level. As father's education was significantly associated with father's occupation ($p<.001$), a decision was made to exclude father's education. For young adult males, BMI, mother's education, consumption of fresh fruit, psychological distress, PA efficacy, social support, life satisfaction, perceived health, perceived importance of PA and participation in organised sports were associated with MVPA mins/week at 20% level of significance at the bivariate model. Outliers and other assumptions of the models were checked and model fit was assessed before finalising the models. To ensure easy interpretations of the results, the regression coefficients were exponentiated into odds ratio (OR) using the *eform* command in Stata. Results are presented as OR with their 95% confidence intervals (CIs). All analyses were

performed in Stata version 14 (StataCorp LP., College Station, Texas) with statistical significance set at *p<.05*.

5.2.4 Results

5.2.4.1 Study participants

During Wave 1, 573 students completed the survey (response rate: 91.6%). Of these, 395 completed the Wave 2 survey (attrition rate: 31.2%). Participants' average age was 20.7±1.35 years at Wave 1 with 45% being female. The baseline characteristics of female and male participants are presented in Table 5.2.1.

In terms of sociodemographic characteristics, the participants were comparable between the waves for measures of: gender (45% female at Wave 1 vs 48% at Wave 2); living with parents (40% vs 75%v for females and 43% vs 44% for males) and university type (public 49% vs 43% for females, 47% vs 39% for males). BMI was comparable for males between the two assessment points with 14% and 17% categorised as obese at Wave 1 and Wave 2, respectively, and slightly more categorised as healthy weight at Wave 2 (77%) than at Wave 1 (68%). Compared to Wave 1, at time 2 fewer female young adults were obese (14% vs 9%) and more had healthy weight (54% vs 78%).

Table 5.2. 1: Baseline characteristics of the participating female and male young adults in Dhaka, Bangladesh, 2015

Characteristics		Females (N=260)	Males (N=313)
		n† (%)	n†† (%)
Body mass index			
	18.50–24.99 kg/m^2	140 (53.9)	213 (68.3)
	<18.50 kg/m^2	83 (31.9)	56 (18.0)
	≥25.00 kg/m^2	37 (14.2)	43 (13.8)
University type			
	Public	128 (49.2)	149 (47.6)
	Private	132 (50.8)	164 (52.4)
Year of study			
	First year	79 (30.4)	105 (33.6)
	Second year	92 (35.4)	131 (41.9)
	Third year	89 (34.2)	77 (24.6)
Mother's highest education attainment			
	Up to secondary (or equivalent)	56 (33.1)	172 (55.0)
	Higher secondary (or equivalent)	61 (23.5)	64 (20.6)
	Tertiary (or equivalent)	113 (43.5)	75 (24.1)
Father's highest education attainment			
	Up to secondary (or equivalent)	30 (11.6)	87 (28.1)
	Higher secondary (or equivalent)	44 (16.9)	58 (18.7)
	Tertiary (or equivalent)	186 (71.5)	166 (53.4)
Mother's employment status			
	Working	54 (20.8)	65 (20.9)
	Stay-at-home	206 (79.2)	246 (79.1)
Father's occupation			
	Government/public service	80 (30.8)	72 (23.3)
	Non-government/private service	41 (15.8)	55 (17.8)
	Professional	26 (10.0)	24 (7.8)
	Self-employed/business	87 (33.5)	91 (29.5)
	Day labourer/farmer	26 (10.0)	67 (21.7)
Monthly gross family income (in BDT)*			
	≤20,000	27 (10.6)	88 (28.4)
	20,001-40,000	69 (27.0)	93 (30.0)
	40,001-70,000	88 (34.4)	84 (27.1)
	>70,000	72 (28.1)	45 (14.5)
Type of accommodation			
	University accommodation/hall	55 (21.2)	91 (29.1)
	Non-university accommodation	205 (78.9)	222 (70.9)

*BDT= Bangladeshi Taka (local currency); 10,000 BDT=117.42 USD as of 15 May 2018
†Total for each variable may not be N=260 due to missing values
†† Total for each variable may not be N=313 due to missing values

5.2.4.2 Physical activity participation

Overall, 17% of the participants met the WHO PA recommendations at Wave 1, and this increased to 23% at Wave 2. The proportion of participants meeting the recommendations was higher among males than females at both Wave 1 (27% v. 6%) and Wave 2 (34% v. 12%).

5.2.4.3 Correlates of physical activity

Table 5.2.2 presents the results of GEE modelling to identify the correlates of MVPA (mins/week). Each of PA efficacy and regular organised sports participation were positively associated with PA for both females and males. However, other correlates differed between female and male respondents. For females, age, PA outcome expectations and life satisfaction were positive correlates, and longer sleep duration was a negative correlate of PA. Psychological distress was negatively associated with PA in male young adults.

Table 5.2. 2: Correlates of physical activity among young adult female and male university students in Dhaka, Bangladesh, 2015-2016*

Factor		Females			Males		
		ORs	95% CI	p-value	ORs	95% CI	p-value
Age (years)							
		1.07	1.01-1.12	**.013**	NS		
Sleep duration (ref: 6.5-8.5 hrs/day)							
	Shorter (<6.5 hrs/day)	0.88	0.74-1.06	.178	NS		
	Longer (>8.5 hrs/day)	0.81	0.68-0.96	**.014**			
PA efficacy (positive construct)							
		1.08	1.06-1.11	**<.001**	1.07	1.03-1.11	**<.001**
PA outcome expectations (positive construct)							
		1.03	1.00-1.05	**.025**	NS		
Organised sports participation (ref: no)							
	Yes	2.26	1.47-3.48	**<.001**	1.95	1.56-2.44	**<.001**
Life-satisfaction (ref: unsatisfied)							
	Neutral	0.93	0.76-1.12	.433	NS		
	Satisfied	1.23	1.04-1.45	**.016**			
Psychological distress (negative construct)							
		NS			0.97	0.94-0.99	**.013**

Values in bold indicate p-value of 0.05 or lower.
* Estimates are based on GEE modelling with physical activity (mins/week) as a continuous dependent variable. Only statistically significant variables (at 5% significance level) are presented.
Abbreviations: CI=Confidence intervals; NS=not significant; OR=odds ratio; PA=physical activity

5.2.5 Discussion

The present study is the first of its kind, and identified socio-demographic, psychological, social, and health and lifestyle correlates of PA among a university-based sample of young adults in Bangladesh. Findings from this one-year prospective study suggest that participation in organised sports and PA efficacy were positively associated with both males' and females PA, and there were gender difference in other correlates. This should be considered when developing PA promotion strategies either across or by gender.

Regular participation in organised sports (at or outside university) was positively associated with PA for both females and males. A recent study with adolescents in Bangladesh, however, reported that involvement in organised sports at school was positively associated with girls' PA, but not boys' (Khan et al. 2017). Organised sports participation, can provide social support and an active social network and so create more opportunities for PA, which in turn can promote activity behaviour during young adulthood (Simons et al. 2015). In Bangladesh, however, many university campuses, mostly private, do not have outdoor sport and activity facilities (e.g., Gym, playground) for organised sport. To promote PA among university-based young adults, universities could provide space and opportunities for organised sports, or consider options to enable access to organised PA opportunities off campus. Private universities have recently started moving to campuses with large spaces, which could offer more opportunities for sport activities.

PA efficacy was positively associated with young adults' PA, which is in accordance with other studies with university-based young adults (Mirzaei-Alavijeh et al. 2018; Rovniak et al. 2002; Shuval et al. 2009). Efficacy is one of the most consistently reported psychological correlates of PA, and considered one of the strongest predictors of PA participation and maintenance (Rhodes et al. 2017; Rovniak et al. 2002). Young adults confidence to participate in PA regularly is perhaps associated with self-regulatory skills such as goal setting, action planning and self-monitoring of PA (Rovniak et al. 2002).

PA outcome expectations have previously been identified as a consistent correlate of adult PA (Rhodes et al. 2017). In the current study, outcome expectations were positively associated with PA of young adult females, but not males. The measure of outcome expectations in the current study focussed on physical fitness, improvements in appearance and health, a reduced risk of poor health, and weight management. Many of these may be more salient to Female young adults; previous research has highlighted that

females are more concerned with appearance and weight management and are more likely to practice a healthier lifestyle (Kilpatrick et al. 2005).

The current study demonstrated some key relationships between indicators of wellbeing and PA, with differences by gender. Psychological distress was negatively associated with only male young adults' PA. This is consistent with a previous study in 46 low-and-middle income countries that reported that a depressive episode (including distress symptoms such as hopelessness, worthlessness) was negatively associated with PA of adult males aged 18-64 years, but not females (Koyanagi et al. 2018). In the current study, life satisfaction was positively associated with females' but not males' PA. An earlier study that found female participants aged 13-19 years who maintained sufficient PA over ten-years had greater life satisfaction than those who were insufficiently active at both time points (Rangul et al. 2012). Longer sleep duration was inversely associated with PA for female young adults only. This is consistent with the 46-country study that found that sleep was positively associated with PA among adult females but not males (Koyanagi et al. 2018). It is possible that the relationship between PA and different aspects of wellbeing e.g., psychological distress, life satisfaction and sleep is bidirectional (Gunnell et al. 2016; Kline 2014). For example, while poor psychological wellbeing may have a negative impact on PA, insufficient PA also can cause poor psychological wellbeing. Further research therefore is needed to understand how different aspects of health and wellbeing are associated with PA, and what role gender plays in relation to these associations.

The strengths of this study include use of prospective data, a PA measure that has been validated in Bangladeshi adults, and examination of a variety of correlates including psychological, social, health and lifestyle and sociodemographic factors to understand PA. Strengths also included the use of a relatively moderately-sized, heterogeneous sample of students from both public and private universities. Limitations include the use of self-report data, including for PA, which are vulnerable to social desirability and recall bias. The study only assessed individual-level correlates of PA as other correlates such as environmental and policy level factors was outside the logistic scope. As the study is based on a non-random convenience sample of university students from a metropolitan city, findings of the study may have limited generalisability, and may not be transferable to all young adults of the country.

5.2.6 Conclusions

Using one-year prospective data, this study has identified a number of psychological, social, lifestyle and sociodemographic correlates of PA among university-based young adults in urban Bangladesh. This information can help to inform pragmatic strategies to promote active lifestyle among Bangladeshi young adults. Improving PA efficacy and creating opportunities for organised sports may help promote PA among both males and females. PA outcome expectations, healthy sleep duration and positive life satisfaction may promote PA participation among young adult females. Young adult males with psychological distress may be vulnerable to low PA. Future studies in this area could include objective measures of PA, a representative sample from urban and regional areas, and follow participants for a longer period.

5.3 Correlates of sedentary behaviour

This manuscript is currently *under review* for possible publication in "*Public Health*". This thesis contains the submitted version of the manuscript. The title (with authors) as follows:

Uddin R, Burton NW, Khan A. Correlates of sedentary behaviour in university-based young adults in Bangladesh: A one-year prospective study.

5.3.1 Abstract

Purpose: To identify correlates of sedentary behaviour (SB) of university-based young adults in Bangladesh.

Methods: Data were from a one-year prospective study with two assessment points. During Wave 1, a convenience sample of 573 students (20.7±1.35 years; 45% female) completed a self-administered survey on SB, physical activity (PA), health, lifestyle, and sociodemographic factors. During Wave 2, 395 students completed the survey (retention rate: 69.3%). SB was assessed with an adapted version of the Global Physical Activity Questionnaire (GPAQ). Generalized Estimating Equations (GEE) was used to identify the correlates.

Results: Overall, 45% participants at Wave 1 and 39% at Wave 2 had high SB of ≥480 mins/day. More females than males had high SB at both assessment points (52% vs. 39% at Wave 1; 46% vs. 32% at Wave 2). Multivariable GEE modelling identified that female gender [OR: 1.08 (95% CI 1.04-1.12)], older age [1.05 (1.01-1.09)], studying in a public university [1.13 (1.08-1.18)], and living with family [1.16 (1.03-1.30)] were positively associated with SB. No other health or lifestyle factors were associated with SB.

Conclusions: SB is prevalent among university-based young adults in Bangladesh with females more sedentary than males. Females, students at public universities, and those living with their family are priority target groups for interventions aimed at reducing SB among university-based young adults in Bangladesh.

5.3.2 Introduction

Young adulthood, encompassing people aged from 18 to 24 years (Jekielek & Brown 2005), is one of the most critical periods of life (Gordon-Larsen et al. 2004). Many significant life events can occur during the transition from adolescence to adulthood, such as gaining full residential independence, moving away from parent's home, commencing work or enrolling in universities. Young adults are likely to make their own lifestyle choices (Hogan 1978; Jekielek & Brown 2005), which may include health compromising behaviours including a sedentary lifestyle with prolonged time watching television, playing video games and using the computer (Gordon-Larsen et al. 2004; Matthews et al. 2008; McVeigh et al. 2016). In general, prolonged sedentary behavior (SB) may have concurrent and future adverse effects on health and wellbeing such as an increased risk of cardio-metabolic diseases (e.g., type 2 diabetes, insulin resistance), weight gain and obesity, and poor psychological wellbeing (Matthews et al. 2008; Nanney et al. 2015; Owen et al. 2010a; Owen et al. 2014; Owen et al. 2010b; Thorp et al. 2011; Voelker 2004; Wilmot et al. 2012).

Contemporary university-based young adults are prime consumers of digital media (Zickuhr 2011), more technology-centred and have more access to and usage of digital technology and other screen-based entertainments (Melton et al. 2014). Furthermore, they spend a significant amount of time studying, which may involve prolonged sitting in the classroom and at home. Thus, university-based young adults may be a high-risk group for prolonged SB, which can adversely influence their health.

A better understanding of the factors associated with SB among young adults can help identify appropriate target groups for interventions to reduce SB (Biddle et al. 2010a). As a relatively new construct, however, SB correlate research is at an early stage and mainly limited to developed countries (O'Donoghue et al. 2016; Owen et al. 2011; Prince et al. 2017) and adults in the general population (Chastin et al. 2015; Prince et al. 2017), or children and adolescents (Hoyos Cillero & Jago 2010; Mielke et al. 2017; Stierlin et al. 2015).

There is some research on correlates of SB with young adults in high-income, and a few in low-and-middle-income countries (LMIC) (Prince et al. 2017). An 18-country study that included 17 LMICs reported that younger age, living off campus (alone or with family members), having depression, and insufficient PA were associated with higher sitting time

among university students aged 16-30 years (Peltzer & Pengpid 2014). A recent study with Turkish university students aged 20.8±1.6 years found that living in a university accommodation, parents lower education level, and having a television/computer in bedroom were associated with higher sedentary screen-time (Caglar et al. 2017). Being underweight, and overweight/obese have been reported to be associated with high internet use among Thai university students aged 18-25 years (Peltzer et al. 2014).

In parallel with many LMICs, Bangladesh is going through rapid urbanisation, industrialisation and modernisation in recent years, which can promote a sedentary lifestyle (Misra & Bhardwaj 2014; Misra et al. 2014). This has implications on young adults, who represent one-fifth of the country's population (United Nations 2016), especially when they have increased access to screen-based entertainments, digital technologies and motorised vehicles (Choudhury 2017; Faruq et al. 2017; Hasnayen & Sultana 2016). The aim of this study, therefore, was to identify sociodemographic, health and lifestyle correlates of SB of university-based young adults in Dhaka city, Bangladesh.

5.3.3 Methods

5.3.3.1 Study population and design

A one-year prospective study with two-time points was conducted with a convenience sample of young adults (18-24 years) recruited from six universities (three public and three private) in Dhaka city, Bangladesh. At Wave 1 (September-December 2015), first, second and third-year undergraduate students from these universities were invited to take part in the study. As fourth-year students were unlikely to be available for a follow-up, they were not invited. Details of the recruitment procedure has been described elsewhere (Uddin et al. 2017). Data were collected with a self-administered written survey, which included items to asses SB, physical activity (PA) behaviours [e.g., at work/transport/leisure, participation in organised sports]; health; lifestyle, and sociodemographic characteristics. Participants completed the Wave 1 survey in approximately 40-45 mins. The Wave 2 survey, which was a sub-set of the Wave 1 survey, took approximately 15-20 mins to complete. The survey was conducted in English. Field-testing with 30 undergraduate students (female 50%) from a university in Dhaka city suggested respondents had no difficulties in understanding the instructions, wording of the questions, and completing the survey.

5.3.3.2 Sedentary behaviour – the outcome variable

An adapted self-administered version of the Global Physical Activity Questionnaire (GPAQ) was used to collect SB data (Chu et al. 2015). The GPAQ was developed by the World Health Organization (WHO) primarily to assess PA in resource-limited countries (Bull et al. 2009). In addition to PA, the GPAQ assesses SB with a single item that asks about time spent in sitting or reclining "at work, at home, getting to and from places, or with friends including time spent sitting at a desk, sitting with friends, traveling by car, bus, train, reading, playing cards or watching television, but do not include time spent sleeping in a typical day of the week" (Armstrong & Bull 2006). The self-administered version of the GPAQ has demonstrated acceptable reliability and validity with the interview version (Chu et al. 2015). As adolescents in Bangladesh report significantly more screen-time during weekend days than weekdays (Khan & Burton 2016), the single item question of the GPAQ was split into two in the current study to ask about SB in a typical weekday and a weekend day.

Daily sedentary time was derived using the following formula and used as a continuous outcome variable:

Daily sedentary time (mins) = [(weekday time (mins)×5) + (weekend day time (mins)×2)]/2

For descriptive purposes, SB was dichotomised as '*low*' (<480 mins/day) and '*high*', (≥480 mins/day). This cut-off has been used in other research with Asian adults (Win et al. 2015), and has been shown to significantly increase the risk of all-cause mortality (Chau et al. 2015). Following the WHO protocol (World Health Organization 2012), four respondents (two each at Wave 1 and 2) were excluded from the analyses as they provided improbable or out of range data.

5.3.3.3 Other measures – the explanatory variables

The following health, lifestyle, and sociodemographic factors measured at Wave 1 were considered as possible correlates of SB.

5.3.3.3.1 Health and lifestyle

Body mass index (BMI) was computed from participants' self-reported height and weight and categorised as healthy (18.50–24.99 kg/m^2), underweight (<18.50 kg/m^2) and

overweight/obese (≥25.00 kg/m^2) based on criteria from the WHO (World Health Organization n.d.-b). Participants were asked to report how frequently they experienced each of five common health problems such as anxiety, depression, stress and sleep difficulties over the past one month. The response options were 'not at all', 'rarely', 'sometimes', 'often' and 'almost always'. Participants were also asked to rate their general health with response options being 'excellent', 'very good', 'good' 'fair' and 'poor'. Participants' PA was measured with the GPAQ; details of PA assessment has been described elsewhere (Uddin et al. 2017). In short, participants were asked whether they engaged in regular PA for each of at work, during transportation and leisure for at least 10 mins continuously, and if so, the number of days in a typical week, and how much time on a typical day. This information was used to compute PA in each of the three domains, which were summed to generate total PA in mins/week (World Health Organization 2010). Total PA was then categorised as insufficient (<150 mins/week) or sufficient (≥150 mins/week); this criterion is consistent with WHO PA recommendations (World Health Organization 2010). Two items assessed if participants engaged in regular organised sports at university or outside university (yes/no). Participants were asked to report if they had each of the following items in their bedroom: TV, a computer and other small screen such as a tablet (yes/no).

Participants completed survey items on cigarette smoking status (non-smoker, past, occasional, regular smoker) alcohol consumption (never drink, used to drink, drink occasionally, drink regularly), and consumption of non-alcoholic carbonated beverages (e.g., Coke, Pepsi, excluding diet Coke or cola type soft drinks) in the past seven days ('none'; '1-2'; '3-4'; '5-6'; '7-9'; '10-13' or '>13' glasses). Participants were also asked the number of days in the past seven days they had breakfast, they brought a homemade lunch to university, and the number of times they consumed some popular food items (e.g., fast food, fruits, vegetables). Dietary behaviour-related items were from a recent study on Bangladeshi adolescents (Khan et al. 2017).

5.3.3.3.2 Sociodemographic factors

The following sociodemographic variables were included: age (collapsed into two groups - 18 to 20 years and 21 to 24 years due to narrow age range); gender; university type (public or private); enrolled program; year of study; mother's and father's education and occupation; living arrangement (e.g., e.g., living alone, with parents); housing type (e.g., own house/flat, university accommodation/hall); and monthly gross household income.

5.3.3.4 Statistical analyses

Proportions of young adults with high SB were identified. This was used to describe the overall and gender-based prevalence of SB over the two assessment points. To identify correlates of SB, total SB mins/day was used as a continuous variable. Due to the non-normal distribution of SB data (mins/day), Generalized Estimating Equations (GEE) with gamma distribution and log link under exchangeable correlation structure was used to identify the correlates of SB. Gamma distribution in GEEs can deal with skewed distribution of outcomes like SB. Both Wave 1 and Wave 2 data were used in GEE to estimate correlates of SB taking into account the non-independence of participants' daily time in SB (mins) nested within two waves.

Explanatory variables which had bivariate associations with SB mins/day at p≤20 [(Maldonado & Greenland 1993)] were identified. Gender; age range; university type; household composition; BMI; meeting the WHO PA guidelines; organised sports participation; frequency of experiencing depression, anxiety, stress and sleep difficulties; perceived health; housing type; TV in bedroom; and mother's education were each associated with SB at the bivariate level. These variables were examined for collinearity before they were included in the multivariable model. Meeting the WHO PA guidelines was significantly associated with organised sports participation (p<.001); hence, a decision was made to exclude organised sports from further analysis. Given that frequency of stress was significantly associated with frequency of sleep difficulties (p<.001), and frequency of anxiety with frequency of depression (p<.001), frequency of stress and anxiety were excluded. Before finalising the model, outliers and other assumptions were checked and model fit was assessed. To ensure easy interpretation of the results, the regression coefficients were exponentiated into odds ratio (OR) using the *eform* command in Stata. Results are presented as OR with their 95% confidence intervals (CIs). All analyses were performed in Stata version 14 (StataCorp LP., College Station, Texas) with statistical significance set at p<.05.

5.3.4 Results

5.3.4.1 Study participants

Of the 575 students who completed the Wave 1 survey (response rate: 91.6%), two provided incomplete data on PA and were excluded from further analysis. Of the 573

remaining, 397 completed the Wave 2 survey (retention rate: 69.3%). Two participants provided incomplete data on PA at Wave 2 and were subsequently excluded from analysis. Participants had an average age of 20.7±1.35 years at baseline with 45% being female. Table 5.3.1 summarises the baseline characteristics of the participants.

The sociodemographic characteristics of Wave 2 respondents were similar to Wave 1 participants for gender (45% vs 48% females during Wave 1 and Wave 2, respectively), being single (94% vs 92%), living with parents (47% vs 52%) and type of university (public 48% vs 42%). BMI was comparable for between the two assessment points with 14% and 13% categorised as obese at Wave 1 and Wave 2 respectively, and more participants categorised as healthy weight at Wave 2 (77%) than at Wave 1 (62%).

Table 5.3. 1: Baseline characteristics of the participating young adults in Dhaka City, Bangladesh (n=573), 2015

Characteristics		n¥	%
Gender			
	Male	313	54.6
	Female	260	45.4
Body mass index			
	18.50–24.99 kg/m^2	353	61.7
	<18.50 kg/m^2	139	24.3
	≥25.00 kg/m^2	80	14.0
University type			
	Public	277	48.3
	Private	296	51.7
Year of study			
	First year	184	32.1
	Second year	223	38.9
	Third year	166	29.0
Mother's educational qualification			
	Up to secondary (or equivalent)	258	45.1
	Higher secondary (or equivalent)	125	21.9
	Tertiary (or equivalent)	188	32.9
Father's educational qualification			
	Secondary (or equivalent)	117	20.4
	Higher secondary (or equivalent)	102	17.9
	Tertiary (or equivalent)	352	61.7
Monthly gross family income (in BDT)*			
	≤20,000	115	20.3
	20,001-40,000	162	28.6
	40,001-70,000	172	30.4
	>70,000	117	20.7
Household composition			
	Living alone or with friends	255	44.7
	Living with parents or other family members	315	55.3

¥ n may not be equal to 573 due to missing values
*BDT=Bangladeshi Taka (local currency); 10,000 BDT=118.03 USD as of 10 May 2018

5.3.4.2 Prevalence of sedentary behaviour

Just under half (45%) of the participants had high SB (≥480 mins/day) at Wave 1, and the percentage was 39% at Wave 2. Prevalence of high SB was more common among females than males at both Wave 1 (52% v. 39% males) and Wave 2 (46% vs. 32%).

5.3.4.3 Correlates of sedentary behaviour

Being overweight; having insufficient PA; frequently experiencing depression, and sleep difficulties; having a TV in the bedroom; living in university accommodation and mother's

higher education were positively associated with SB, and better-perceived health negatively associated with SB, in the bivariate analyses. In the multivariable modelling, however, these variables had no significant association with SB. Table 5.3.2 presents the statistically significant correlates of SB among the university-based young adults in Bangladesh.

Table 5.3. 2: Individual-level correlates of sedentary behaviour among young adults in Dhaka, Bangladesh, 2015-2016*

Factors		OR[a]	95% CI	p-value
Gender				
	Male	Ref		
	Female	1.08	1.04 - 1.12	<.001
Age range				
	18-20 years	Ref		
	21-24 years	1.05	1.01 - 1.09	.015
University type				
	Private	Ref		
	Public	1.13	1.08 - 1.18	<.001
Household composition				
	Living alone or with friends	Ref		
	Living with family	1.16	1.03 - 1.03	.006

* Estimates are based on GEE modelling with SB (mins/day) as a continuous dependent variable. Only statistically significant variables at 5% level are presented.
[a] Odds ratios are exponentiated regression coefficients.
Abbreviations: CI=Confidence intervals; OR=odds ratio; SB=sedentary behaviour

5.3.5 Discussion

Using one-year prospective data, this study identified a number of specific sociodemographic correlates of SB among university-based young adults in Dhaka City, Bangladesh. Health and lifestyle factors were not significantly associated with SB.

The finding that female young adults were more likely than their male counterparts to have prolonged SB is inconsistent with an 18-country study, including 17 LMICs, with university students aged 16-30 years (Peltzer & Pengpid 2014), which reported gender unrelated to SB. That earlier study, however, did not provide any country-specific correlates of SB. The earlier study used the International Physical Activity Questionnaire (IPAQ) to assess daily sitting time across different contexts only for weekdays, and did not include time spent in SB during weekend days. It may be, therefore, that weekend SB contributes to significant differences by gender. The findings of the present study are also inconsistent with a previous study of adolescents in Bangladesh, which reported boys were more likely to have higher sedentary screen-time than girls (Khan & Burton 2016).

However, that study assessed only screen-time, which is only one type of SB. The high prevalence of SB among females in the current study may reflect that, in Bangladesh, female university students are more committed to sedentary academic activities than males. It is possible that non-screen based SB such, as reading books, accounted for a large proportion of young females' time. More research with young adults is needed to understand the role of gender on context specific SB in Bangladesh.

Young adults aged 21 to 24 years were likely to be more sedentary than those 18-20 years. This is inconsistent with a previous study in LMICs that reported younger age (16-19 years) associated with higher sitting time among university students (Peltzer & Pengpid 2014). That study used a more aged varied sample (16-30 years). The age bracket used in this current study perhaps did not allow capturing the real changes in SB. This relationship found in the current study, however, is consistent with other research reporting a positive association between age and SB among different population groups (Bauman et al. 2018; O'Donoghue et al. 2016). During adolescence, active playtime is displaced by sedentary screen-time (Bauman et al. 2018), which perhaps continues to young adulthood.

In Bangladesh, private universities are primarily accessible to high-income families, and a previous study with adolescents in Bangladesh reported that high-income was associated with more screen-based sedentary time (Khan & Burton 2016). Therefore, private university students were expected to be more sedentary; however, the present study found the opposite results that higher SB was associated with studying in public universities. Future research could examine why public university students are more likely to be sedentary than private university students in Bangladesh, and if this reflects socioeconomic status or other factors.

Living with family was positively associated with young adults' high SB in this study. Students who live with their family may have less family responsibilities e.g., household chores, which may create more opportunities for SB, such as recreational screen time or study. Unlike those young adults living alone or with others, it may be that young adults living in the family home are less constrained by paid work (Berngruber 2016) or '*housekeeping*' responsibilities, which may also provide more time for SB.

Findings that BMI had no significant association with SB is consistent with a previous study with university students in 17 LMICs that also found no association

between BMI and sitting-time (Peltzer & Pengpid 2014). A recent study with adolescents in Bangladesh also did not find BMI to be associated with recreational screen-time (Khan & Burton 2016). According to a recent systematic review, 17 out of 25 studies with adults aged 18-65 years (mainly in developed countries) found a positive association between recreational screen-use and BMI (O'Donoghue et al. 2016). It is possible that the association between BMI and SB is age-specific. More research with young adults is needed to understand this relationship.

This is the first study, to our knowledge, that identified correlates of SB among university-based young adults in South Asia using prospective data. Other strengths of this study included a moderately large sample size, and a heterogeneous sample of students from both public and private universities. The study has, however, some limitations. The self-reported measure to assess SB may be vulnerable to recall bias. Use of a non-random sample of participants from conveniently selected universities in a metropolitan city may have limited representativeness, so findings of this study may not be transferable to all young adults in Bangladesh.

5.3.6 Conclusions

SB has become pervasive among university-based young adults in Bangladesh. Females, students in public universities, and students who live with their family may be vulnerable to high SB. More prospective research with objective measures of SB and a population-based large representative sample with longer follow-up period is needed to develop a comprehensive understanding of the correlates of SB among Bangladeshi young adults.

5.4 Factors associated with changes in activity behaviours

This manuscript is currently *under review*. This thesis contains the submitted version of the manuscript. The title (with authors) as follows:

Uddin R, Burton NW, Khan A. What factors are associated with changes in physical activity and sedentary behaviour over one year among university-based young adults?

5.4.1 Abstract

Background: To identify correlates of changes in physical activity (PA) and sedentary behaviour (SB) among university-based young adults in Bangladesh.

Methods: Data were from a one-year prospective study with two assessment points (n= 573 at baseline, aged 20.7±1.35 years, 45% female; retention rate 69%). Participants completed a self-administered written survey on PA, SB, health and lifestyle behaviours, and sociodemographics. Changes in PA were categorized as: negligible (±<60mins/week), >60mins/week decrease or >60mins/week increase. Changes in SB were categorised as negligible (±<120mins/week), >120mins/week decrease and >120mins/week increase. Multinomial logistic regression analysis was used to identify the correlates.

Results: About three-quarters (72%) of participants had insufficient PA at both assessment points. Of those who were sufficiently active at Wave 1, 5% became insufficiently active at Wave 2. One-quarter of participants (23%) had high SB at Wave 1 and Wave 2. Of those who had low SB at Wave 1, 16% had high SB at Wave 2. Being male [2.04 (1.06-3.93)], baseline phone time of >2hrs/day [3.14 (1.04-7.04)] and not participating in organised sports at baseline [2.56 (1.24-5.29) were associated with a decrease in PA by >60mins/week. Participants who frequently experienced stress at baseline had higher the odds of increasing SB by >120mins/day [1.83 (1.04-3.23)].

Conclusions: SB is more variable than PA over one year in university-based young adults in Bangladesh. Males, those with high phone time, those not engaging with organised sports, and those with frequent stress may change to a more inactive lifestyle.

5.4.2 Introduction

Physical activity (PA) participation among young adults can provide diverse health benefits such as lower cardiometabolic risk factors of non-communicable diseases (NCD), and help with weight maintenance (Gordon-Larsen et al. 2009; Jakicic et al. 2015). Young adults who participate in sufficient PA have been found to have better psychosocial and cognitive health including lower levels of anxiety and depression, and higher self-esteem and life satisfaction than their inactive counterparts (Korn et al. 2013; Rangul et al. 2012; Tyson et al. 2010). Emerging evidence also suggests that prolonged sedentary behaviour (SB), such as sitting and screen time, is associated with chronic health conditions including cardio-metabolic disorders, overweight and obesity, stress, sleep difficulties, anxiety and depressive disorders among young adults (Feng et al. 2014; Nanney et al. 2015; Wu et al. 2016; Wu et al. 2015).

PA decreases during late adolescence especially for leisure-time sports and active transport (Corder et al. 2017; Neumark-Sztainer et al. 2003; Van Dyck et al. 2015). Because of modernisation, labour-saving technologies, advances in transportation, and increased availability of and access to screen-based entertainments, contemporary young adults spend a significant amount of time in different sedentary pursuits (Biddle et al. 2012). The increase in SB also continues over adulthood (Bauman et al. 2018; O'Donoghue et al. 2016; Richardson et al. 2012; Smith et al. 2015). Being at university may affect PA and SB among young adults. For example, there may be new opportunities for PA via campus organised sports and social networks. However, academic commitments may prolong SB for study and reduce discretionary time for PA.

Most correlate studies of PA and SB have used cross-sectional data (Bauman et al. 2012; Corder et al. 2017; Gordon-Larsen et al. 2004; O'Donoghue et al. 2016; Prince et al. 2017). However, the correlates of current behaviour may not be the same as the factors associated with change of that behaviour over time (Brug et al. 2005). A few studies have assessed factors associated with change in PA among adolescents (Dumith et al. 2012; Nader et al. 2008; Raudsepp & Viira 2008). Male gender and greater outdoor exposure were associated with an increase (Dumith et al. 2012; Nader et al. 2008), and low family income and higher level of body mass index (BMI) were associated with a decrease (Nader et al. 2008; Raudsepp & Viira 2008) in adolescents PA over time. There is however little evidence on young adults, and we are not aware of studies that have looked at change in both PA and SB. Understanding the factors associated with PA and SB change

can help identify those at risk of adopting an unhealthy lifestyle, and therefore adverse health and wellbeing outcomes. The aim of the current study was, therefore, to identify the factors associated with one-year change in PA and SB among university-based young adults in Dhaka, Bangladesh.

5.4.3 Methods

5.4.3.1 Study population and design

Data were from a one-year prospective study with two-assessment points. During Wave 1 (September to December 2015), a convenience sample of first, second and third-year students (18-24 years) were recruited from six universities (three public and three private) in Dhaka city, Bangladesh. Details of the recruitment procedure have been discussed elsewhere (Uddin et al. 2017). Participating students completed a written self-administered written survey with questions about PA, SB, psychological and social factors (e.g., stress, social support), health and lifestyle behaviours (e.g., weight, cigarette smoking), and sociodemographic factors. Participants completed Wave 1 survey in approximately 40-45 mins. In 2016 (October to November 2016), the students were followed up with a survey that included questions on PA and SB, and took about 15-20 mins to complete. One university (n=84; 15% of Wave 1 participants) decided not to participate in Wave 2, although initially they did agree to participate in both waves of the study.

5.4.3.2 Outcome variables – change in physical activity and sedentary behaviour

PA was measured with the Global Physical Activity Questionnaire (GPAQ) (Bull et al. 2009). Participants were asked whether they engaged in regular PA for each of at work, during transportation and leisure for at least 10 mins continuously, and if so, the number of days in a typical week, and how much time on a typical day. This information was used to compute PA times in each of the three domains, which were then summed to generate total PA in mins/week (World Health Organization 2010). For descriptive purposes, PA was categorised as ‘insufficient’ (<150 mins/week) and ‘sufficient’ (≥150 mins/week); this criterion is consistent with World Health Organisation’s (WHO) PA recommendations for adults (World Health Organization 2010). To examine changes in PA over one-year, Wave 1 PA time (mins/week) was subtracted from Wave 2 PA time. These data were then categorised into one of three groups: negligible change ±≤60 mins/week

increase/decrease in physical activity; decreased by >60 mins/week, and increased by >60 mins/week.

An adapted version of the GPAQ was used to assess SB. The GPAQ has one item asking about time spent sitting/reclining "at work, at home, getting to and from places, or with friends including time spent sitting at a desk, sitting with friends, traveling by car, bus, train, reading, playing cards or watching television, but do not include time spent sleeping in a typical day of the week" (Armstrong & Bull 2006). As adolescents in Bangladesh reported significantly more screen-time (the most common type of SB among adolescents) during weekend days than weekdays (Khan & Burton 2016), the single item question of the GPAQ was split into two in the current study to ask about SB in a typical weekday and a weekend day using the same GPAQ wording. Daily sedentary time was derived from weekend day and weekday SB data. For descriptive purposes, SB was dichotomised as high (>480 mins/day) and low (≥480 min/day). This cut-off of has been used in other research with Asian adults (Win et al. 2015), and has been shown to significantly increase the risk of all-cause mortality (Chau et al. 2015). To examine changes in SB over one-year, Wave 1 SB time (mins/day) was subtracted from Wave 2 SB time. These data were then categorised into one of three groups: negligible change = ±≤120 mins/day; increase by >120 mins/day, and decrease by >120 mins/week.

Following the WHO GPAQ scoring protocol (World Health Organization 2012), two respondents at each wave (n=4), were excluded from the analyses as they provided improbable or out of range PA data.

5.4.3.3 Explanatory variables

Sociodemographic, health, and lifestyle variables measured at Wave 1 were considered as possible factors associated with change in PA and SB. PA specific psychological and social factors measured at Wave 1 were considered as predictors of change in PA only.

5.4.3.3.1 Sociodemographics

Sociodemographic variables included: age; gender; marital status; each of parent's highest education attainment; mother's employment status; father's occupation; university type; monthly gross household income; living arrangement and type of accommodation; and having TV and/or computer in bedroom.

5.4.3.3.2 Health and lifestyle factors

The following health and lifestyle factors were assessed: frequency of experiencing each of anxiety, depression, stress, and sleep difficulties; perceived health, life satisfaction, body mass index (BMI); cigarette smoking status; alcohol consumption; dietary behaviour (e.g., frequency of fast food, fruit, sugary drinks; breakfast skipping); participation in organised sports at university or outside university.

5.4.3.3.3 Physical activity specific psychological and social variables

PA efficacy was measured with 5-items using a 4-point Likert scale for responses. Items asked about confidence overcoming barriers to PA if they had worries, felt depressed, felt tense, felt tired, and were too busy to do PA (Schwarzer & Renner 2009). An exploratory factor analysis with varimax rotation offered a one-factor solution that accounted for 52% variance, with Cronbach's alpha being 0.85. Scores were summed and a total PA efficacy score (range: 5-20) was generated with high scores representing high efficacy.

PA outcome expectations were assessed using five items from the Benefits of Physical Activity scale (Sallis et al. 1989) to assess anticipated benefits of regular PA including improving physical fitness, appearance, and overall health; helping with weight management, and reducing the risk of poor health. Responses were recorded on a 5-point Likert scale. An exploratory factor analysis with varimax rotation confirmed the unidimensionality of the five items with a one-factor solution that accounted for 56% of the variance, with Cronbach's alpha being 0.79. Scores were summed to generate an outcome expectations score (range: 5-25) with high scores representing positive outcome expectations.

Perceived importance of PA was measured with a single item. Participants were asked to indicate how important they think PA in their life on a 6-point Likert-scale.

Ten items from the Social Support for Exercise Survey Scale (Sallis et al. 1987) were used to measure social support for PA. Participants used a 5-point Likert-scale to indicate how often they received PA support from their family/friends (e.g., did PA with the participant, gave encouragement, complained about their PA). An exploratory factor analysis with varimax rotation confirmed the unidimensionality of the 10 items with a one-factor solution accounting for 91% of the variance with Cronbach's alpha being 0.87. The item scores were summed to generate a total PA social support score (range: 6-36; one item was reverse scored) with high scores representing high level of social support for PA.

5.4.3.4 Statistical analyses

To identify the correlates of changes in PA and SB, one-year prospective data were used. As the outcome variables (changes in PA and SB) had three categories (negligible change, decrease and increase), multinomial logistic regression analysis was used to identify correlates of changes. Explanatory variables which had univariate associations with the outcome variable at ≤20% significance level [as used elsewhere (Maldonado & Greenland 1993)] were identified and examined for collinearity. Outliers and other assumptions of the models were checked and model fit was assessed before finalising the model. Variables, which had insignificant associations with the outcome variable of interest in the multivariable model at 5% level of significance, were excluded.

The modelling of three categories for PA changes involved estimation of the following two equations:

i) The likelihood of '*decrease'* in PA over one-year vs the likelihood of '*negligible change*', and
ii) The likelihood of '*increase'* in PA over one-year vs the likelihood of '*negligible change'*.

The modelling of three categories for SB changes involved estimation of the following two equations:

i) The likelihood of '*increase'* in SB over one-year vs the likelihood of '*negligible change*', and
ii) The likelihood of '*decrease'* in SB over one-year vs the likelihood of '*negligible change'*.

All analyses were performed in Stata version 14 (StataCorp LP., College Station, Texas) with statistical significance set at $p<.05$. Only significant factors associated with change are presented as odds ratios (OR) with their 95% confidence intervals (CI).

5.4.4 Results

5.4.4.1 Participants

A total of 575 students completed the Wave 1 survey. Two of Wave 1 participants were excluded as they provided incomplete data on PA. Among 573 students who participated in Wave 1, 397 completed Wave 2 survey. However, two participants provided incomplete data at Wave 2 and were excluded. Thus, the analytical sample of this study was n=395.

Just over half of the participants who participated in both assessment points were female, the majority were single, had healthy BMI and were studying in public universities. Four out five of the participants' mother were stay-at-home, one-third of participants had a mother with a tertiary education, and three out of five reported their father had tertiary education. Characteristics of students who participated in both waves are presented in Table 5.4.1.

Table 5.4. 1: Characteristics of the participating young adults in Dhaka City, Bangladesh, 2015-2016, (n=395)[a]

Characteristics		n	%
Age (years)			
	18-20	184	46.6
	21-24	211	53.4
Gender			
	Male	190	48.1
	Female	205	51.9
Marital status			
	Single	365	92.4
	Married or others	30	7.6
BMI			
	Healthy weight	91	23.0
	Underweight	248	62.8
	Overweight	56	14.2
University type			
	Public	163	41.3
	Private	232	58.7
Mother's educational qualification			
	Up to secondary (or equivalent)	178	45.1
	Higher secondary (or equivalent)	84	21.3
	Tertiary (or equivalent)	133	33.7
Father's educational qualification			
	Up to secondary (or equivalent)	75	19.0
	Higher secondary (or equivalent)	82	20.8
	Tertiary (or equivalent)	237	60.2
Mother's employment status			
	Working	83	21.1
	Stay-at-home	310	78.9
Father's occupation			
	Government/ public service	103	27.9
	Non-government/ private service	63	17.1
	Professional	31	8.4
	Self-employed/ business	139	37.7
	Farmer/ day labourer	33	8.9
Monthly gross family income (in BDT)*			
	≤20,000	74	19.0
	20,001-40,000	98	25.1
	40,001-70,000	125	32.1
	>70,000	93	23.9

[a] n=395 includes those who participated in both Waves.
*BDT=Bangladeshi Taka (local currency); 10,000 BDT=120.52 USD as of 29 Apr. 2018

5.4.4.2 Physical activity

As shown in Figure 5.4.1, of the 395 students who participated in both waves of the study, just less than three-quarters (72%) remained insufficiently active at both assessment points with more females insufficiently active than males. One in ten (10%) participants who had insufficient PA at Wave 1 became sufficiently active at Wave 2 with more males (12%) than females (8%) becoming sufficiently active at Wave 2. Overall, 5% participants who had sufficient PA at Wave 1 became insufficiently active at Wave 2 with less females (2%) than males (8%) becoming insufficiently active at Wave 2. Overall, 13% were sufficiently active at both waves, with more males sufficiently active than females.

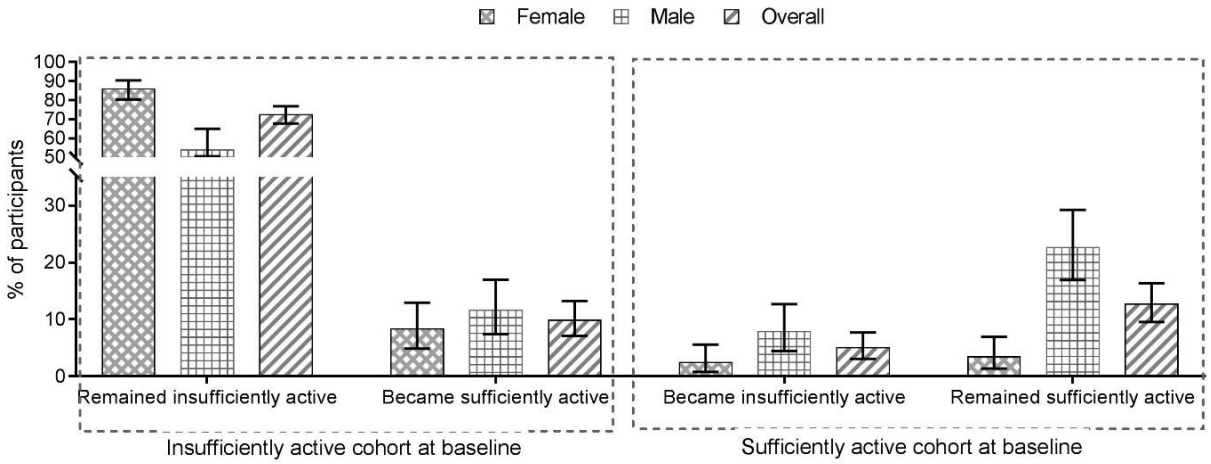

Figure 5.4. 1: Changes in meeting the World Health Organisation's physical activity recommendations (≥150 mins/week) across one year among young adults in Dhaka city, Bangladesh, by gender, 2015-2016 (n=395)[a]

[a] n=395 includes those who participated in both Waves.
Note: Error bars represent 95 confidence intervals

Gender, age range, mother's occupation status, father's education, computer in bedroom, social support for PA, PA efficacy, perceived importance of PA, organised sports participation, perceived health, sleep difficulties, vegetable consumption, daily phone time and SB had a univariate association with PA change at 20% level of significance. Male gender, >2hrs/day phone time and no organised sports participation were associated with a decrease in PA by >60mins/week in the multivariable model. Participants who had a stay-at-home mother had twice the odds of increasing PA by >60 mins/week (Table 5.4.2).

Table 5.4. 2: Factors associated with one-year change in physical activity among university-based young adults in Dhaka city, Bangladesh, 2015-2016 (n=395)[a]

Characteristics		>60 min/week decrease vs. ±≤60 min/week change in PA		>60 min/week increase vs. ±≤60 min/week change in PA	
		OR (95% CI)	p-value	OR (95% CI)	p-value
Gender					
	Female	Ref		Ref	
	Male	2.04 (1.06-3.93)	**.032**	0.99 (0.57-1.73)	.976
Stay-at-home mother					
	No	Ref		Ref	
	Yes	1.09 (0.53-2.27)	.808	2.26 (1.09-4.70)	**.029**
Phone time					
	≤ 1hr/day	Ref		Ref	
	1-2 hr/day	0.77 (0.35-1.70)	.523	0.96 (0.52-1.77)	.907
	> 2 hr/day	2.11 (1.01-4.41)	**.048**	0.82 (0.38-1.78)	.615
Organised sports participation					
	Yes	Ref		Ref	
	No	2.56 (1.24-5.29)	.**011**	1.55 (0.74-3.24)	.242

Values in bold indicate p-value of <0.05.
[a] n=395 includes those who participated in both Waves.
Note: Initial model included variables that had a univariate association with the outcome variable at 20% level of significance. Variables were removed from each of the models until only variables with a p-value <0.5 remained.
Abbreviations: OR = odds ratio; CI = confidence intervals; PA = physical activity

5.4.4.3 Sedentary behaviour

About one-quarter of participants (23%) had high SB at both waves with more females than males. One-quarter of participants (25%) who had high SB at Wave 1 had low SB at Wave 2 with the percentage similar for males and females at Wave 2. Just over one-third of participants (36%) had low SB (<480 mins/day) at both waves, with more young adult males than females. Overall, 16% participants who had low SB at Wave 1 had high SB at Wave 2 with a similar percentage between females and males (Figure 5.4.2).

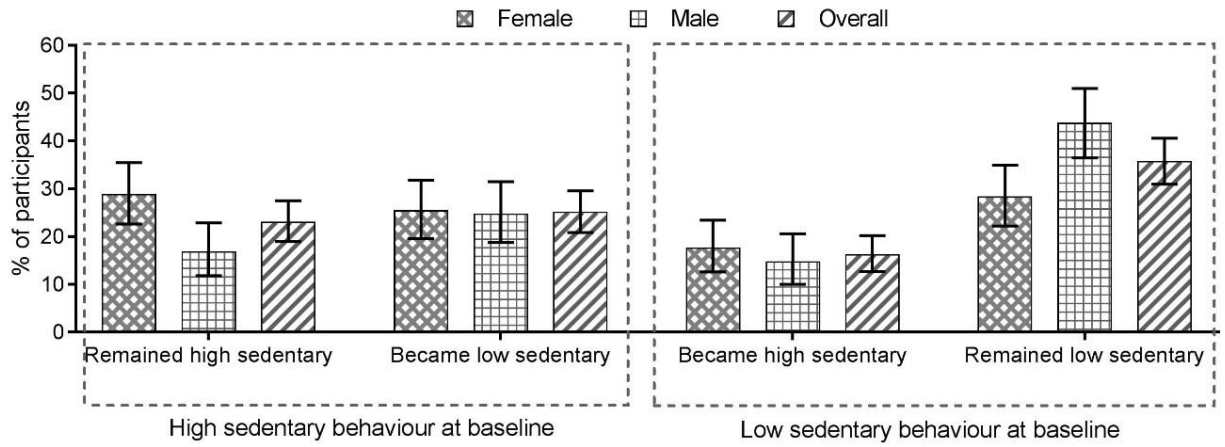

Figure 5.4. 2: Changes in sedentary behaviour (>8hrs/day) across two waves among young adults in Dhaka city, Bangladesh, by gender, 2015-2016 (n=395)[a]

[a] n=395 includes those who participated in both Waves.
Note: Error bars represent 95 confidence intervals

BMI, father's occupation, frequency of stress, current cigarette smoking, low vegetable consumption, not meeting the WHO PA recommendation of ≥150 mins/week and skipping breakfast had univariate association with change in daily SB at 20% level of significance. Being overweight and meeting the WHO PA recommendations were associated with a decrease in SB by >120 mins/day. Frequently experiencing stress was associated with an increase in SB by >120 mins/day. Table 5.4.3 presents factors, which were significantly associated with changes in SB among in the multivariate models.

Table 5.4. 3: Factors associated with one-year change in sedentary behaviour among university-based young adults in Dhaka city, Bangladesh, 2015-2016 (n=395)[a]

Characteristics		Daily >120 min decrease vs. ±≤120 min change		Daily >120 min increase vs. ±≤120 min change	
		OR (95% CI)	p-value	OR (95% CI)	p-value
BMI					
	Healthy	Ref		Ref	
	Underweight	1.39 (0.76-2.53)	.286	1.46 (0.76-2.80)	.252
	Overweight	3.26 (1.64-6.47)	**.001**	1.86 (0.81-4.30)	.146
Experiencing stress					
	Infrequently	Ref		Ref	
	Frequently	1.36 (0.81-2.29)	.247	1.83 (1.04-3.23)	**.036**
Meeting the WHO physical activity recommendations					
	No	Ref		Ref	
	Yes	1.97 (1.07-3.65)	**.030**	1.48 (0.72-3.03)	.288

Values in bold indicate p-value of <0.05.
[a] n=395 includes those who participated in both Waves.
Note: Initial model included variables that had a univariate association with the outcome variable at 20% level of significance. Variables were removed from the models until only variables with a p-value <0.5 remained.
Abbreviations: OR=odds ratio; CI=confidence intervals; WHO=World Health Organization

5.4.5 Discussion

To our knowledge, the current study is the first to identify the factors associated with change in PA and SB among young adults in an LMIC. Contemporary PA/SB research often focusses on cross-sectional correlates of these behaviours, and less attention has been paid to understand which factors are associated with change in PA/SB over time. This information can help identifying specific population groups who are at risk of compromising their activity behaviours. In this current study of university-based young adults, males, and participants with high phone time and those who did not engage in organised sports at baseline were likely to decrease their weekly PA over one year. Young adults who frequently experienced stress at baseline had higher odds of increasing SB. In terms of change to a healthy lifestyle, university students with a stay at home mother were more likely to increase PA, and those who were overweight or meeting PA recommendations were more likely to decrease SB over the year.

In the entire sample, 85% of the participants' maintained their PA status over the year, with 72% remaining insufficiently active and 13% remaining sufficiently active at both assessment points based on the WHO PA recommendations of ≥150 mins/week. Of those who were sufficiently active at Wave 1, 5% became insufficiently active. Notably, overall, 59% participants maintained their SB status, with 36% of participants remaining low SB at

and 23% remaining high SB at both assessment points. Over one-year, 16% of participants who had low SB at Wave 1 had high SB at Wave 2. Findings of the current study therefore suggest that SB is more variable than PA among university-based young adults in Bangladesh. This may reflect that PA status among young adults is more habitual than SB. In addition, SB includes a wider range of behaviours, with recreational and non-recreational activities, which could increase variability.

PA decrease was more common among males, those with high phone time, and those not engaging with organised sports. Males had twice the odds of decreasing PA by more than 60 mins/week over the year; however, gender had no significant association with increase in PA. A higher number of males than females were sufficiently active at both Wave 1 (27% vs. 6%) and Wave 2 (34% vs. 12%). In general, male gender is positively associated with PA regardless of country or age group (Bauman et al. 2012). Participants who had high phone time of >2 hrs/day had higher the odds of decreasing their PA over the year. Phone conversations tend to be sedentary, which can displace and decrease PA time. Engaging in high phone time may also suggest prioritisation of social activities. Young adults who did not participate in organised sports were more likely to decrease their PA over the year. This is understandable as organised sports can create a PA friendly environment for young adults. Organised sports can also provide a social network, which can be important for the adoption and maintenance of different health-enhancing behaviours (Christakis & Fowler 2007; Janssen et al. 2014).

Participants who frequently experienced stress had higher the odds of increasing daily sedentary time. This supports the current literature that poor psychological health is associated with high SB among university-based young adults (Feng et al. 2014; Wu et al. 2016; Wu et al. 2015) and in the general population (O'Donoghue et al. 2016; Prince et al. 2017). This relationship, however, could be bidirectional (Gunnell et al. 2016). While people can be sedentary in response to high levels of stress, it is also possible that a sedentary lifestyle contributes to stress, poor psychological functioning, disturbed sleep, anxiety and depression, (Gunnell et al. 2016; Hamer & Smith 2018). More research is needed to understand the causal pathways of stress and SB. Findings suggest that students who had a stay-at-home mother were more likely to increase their PA over one-year. This contrasts a previous cross-sectional study with adolescents in Bangladesh (Khan et al. 2017) that reported a positive association between mother working and boys' PA, and highlights the need to differentiate between correlates of current and change behaviour. University students spend a significant amount of time on campus. It is possible

that when mothers stay at home they have more time to provide support (e.g., encouragement, transportation) for PA. It would be interesting to assess how parental occupation affect PA at different stages of life from childhood, adolescence to young adulthood.

Overweight participants had higher odds of decreasing their daily sedentary time, which is inconsistent with other research indicating a positive association between BMI and SB (O'Donoghue et al. 2016). It is possible that overweight students were more health conscious and therefore trying to do less SB over time. Findings that participants who met the WHO recommendations of PA were more likely to decrease their SB than those who did not meet the recommendations, can be explained by time displacement (Rhodes & Blanchard 2011). As suggested in Behavioural Choice Theory (Rachlin et al. 1980), one behaviour may compete with another during free time; time spent in one behaviour can affect and displace time for another. It is thus possible that participation in PA reduced time in SB. It may be that those who were physically active were less interested in sedentary pursuits such as recreational screen time.

The strengths of this study include PA and SB measures that have been validated in Bangladeshi adults, a moderately large sample size, and a heterogeneous group of students representing both public and private universities. The study, however, has some limitations. Self-reported measures to assess PA and SB are vulnerable to social desirability and recall bias and self-report of SB can be difficult given the incidental and varied nature of this type of behaviour. The use of a non-random sample of participants from conveniently selected universities in a metropolitan city may limit the generalisability of the findings.

5.4.6 Conclusions

The results of this study suggest that SB is more variable than PA among university-based young adults in Dhaka, Bangladesh with more young adults maintaining their PA status than SB status. Males, participants with high phone time, those not engaging in organised sports, and those with frequent stress were more at risk of compromising their activity behaviours. Research with more assessment points (to understand trajectory) and representative samples of young adults from metropolitan and regional areas are needed to confirm these findings.

Chapter 6: Physical activity, sedentary behaviour and psychological wellbeing

Uddin R, Burton NW, Khan A. Combined effects of physical inactivity and sedentary behaviour on psychological distress among university-based young adults: A one-year prospective study [*under review*]

Contributor	Statement of contribution (Chapter 6 – Section 6.1)
Riaz Uddin (Candidate)	Conception and design (50%); analysis and interpretation (50%); drafting and production (50%)
Nicola W Burton	Conception and design (25%); analysis and interpretation (20%); drafting and production (20%)
Asaduzzaman Khan	Conception and design (25%); analysis and interpretation (30%); drafting and production (30%)

Uddin R, Burton NW, Khan A. Effects of physical inactivity and sedentary behaviour on sleep difficulties among young adults: A one-year prospective study [*under review*]

Contributor	Statement of contribution (Chapter 6 – Section 6.2)
Riaz Uddin (Candidate)	Conception and design (50%); analysis and interpretation (50%); drafting and production (50%)
Nicola W Burton	Conception and design (25%); analysis and interpretation (20%); drafting and production (20%)
Asaduzzaman Khan	Conception and design (25%); analysis and interpretation (30%); drafting and production (30%)

Physical activity, sedentary behaviour and psychological wellbeing

Chapter 6 addresses two research questions and is composed of two sections – section 6.1 and 6.2 examining the effects of physical activity (PA) and sedentary behaviour (SB) on psychological wellbeing of Bangladeshi young adults (*Objective 3*). Both of these sections are based on one-year prospective data. Section 6.1 as a manuscript is *under review* and presents the associations of PA and SB with psychological distress (Research question 7). Section 6.2 as a manuscript is also *under review* and presents the associations of PA and SB with sleep difficulties (Research question 8).

6.1 Physical inactivity and sedentary behaviour and psychological distress

This manuscript is currently *under review*. The title (with authors) as follows:

Uddin R, Burton NW, Khan A. Combined effects of physical inactivity and sedentary behaviour on psychological distress among university-based young adults: A one-year prospective study.

6.1.1 Abstract

Insufficient physical activity (PA) and prolonged sedentary behaviour (SB) may have deleterious psychological health consequences. Using one-year prospective data, this study examined the combined effects of PA and SB on psychological distress among university-based young adults in Dhaka, Bangladesh. During Wave 1 (September to December 2015), total 573 undergraduate students (average age: 20.7±1.35 years; 45% female) completed a self-administered survey on PA, SB, psychological distress, health and lifestyle factors and sociodemographics. During Wave 2 (October-November 2016), 395 students (retention rate=69%) completed a sub-set of Wave 2 survey with items on PA, SB and psychological distress. PA and SB were assessed using the Global Physical Activity Questionnaire (GPAQ) and distress with the Kessler 6 Psychological Distress (K6) scale. Generalized Estimating Equations (GEE) with *Gaussian* family and *identity* link under *exchangeable* correlation structure was used to examine the relationships. Multivariable modelling showed that participants with insufficient PA (<150 minutes/week) and high SB (≥480 minutes/day) or insufficient PA + low SB had more distress [ß: 3.07 (95%CI: 2.12-4.01) and 2.77 (1.86-3.67), respectively] than those who had sufficient PA + low SB, after controlling for gender, sleep difficulties, perceived health, fast food and fresh fruit intake. There was no statistically significant difference for the level of distress between other PA and SB groups. In this one-year prospective study, irrespective of SB, insufficient PA was associated with high psychological distress in university-based young adults in Bangladesh. The protective role of PA should be considered in intervention programs to improve the psychological health of young adults.

6.1.2 Introduction

Approximately three-quarters of psychological health problems appear by the age of 20 years (World Health Organization n.d.-a). Worldwide, poor psychological health has been reported as the most common cause of disability in adolescents and young adults aged 10-24 years, contributing to 45% of years lost due to disability (YLD) (Gore et al. 2011). Globally, unipolar depressive disorders are the leading cause of non-fatal burden of disease in young adults aged 20-24 years, representing approximately 8% of total disability-adjusted life-years (DALYs) lost (Gore et al. 2011). Poor psychological health may compromise psychosocial development, increase substance abuse, lower academic performance and achievements, cause unemployment and decrease the quality of life (Bayram & Bilgel 2008; Bruffaerts et al. ; Gibb et al. 2010; Patel et al. 2007).

Physical activity (PA) participation has been inversely associated with general young adults' poor psychological health in longitudinal (Ströhle et al. 2007) and intervention studies (Al-Eisa et al. 2014; Ghorbani et al. 2014; Li et al. 2015). PA can reduce the risk of anxiety and depressive symptoms, and stress; and improve the psychosocial wellbeing of young adults (Al-Eisa et al. 2014; Ghorbani et al. 2014; Li et al. 2015; Ströhle et al. 2007). In contrast, sedentary behaviour (SB), defined as waking time spent in sitting or reclining; e.g., watching television (TV), computer use, in travel (e.g., in motorised vehicles), has been positively associated with poor psychological health in young adults (Edwards & Loprinzi 2016; Wu et al. 2016). For example, a recent longitudinal study in Chinese college students reported that high screen-time was associated with poor psychological health, and an increase in screen-time was associated with progression of psychological health problems during one-year follow-up (Wu et al. 2016).

Insufficient PA and high SB may interact to increase psychological health problems (Cao et al. 2011; Feng et al. 2014; Khan & Burton 2017; Khan et al. 2018; Wu et al. 2015). For example, a recent cross-sectional study in Chinese college students reported that participants who had insufficient PA (<3 days/week of exercise) and high SB (>2 hours/day screen-time) were more likely to report depression, anxiety, and other psychopathological symptoms than those who had sufficient PA and low SB (Wu et al. 2015). However, the strength of this evidence is limited by a cross-sectional study design.

University students may be vulnerable to poor psychological health because of academic and social demands in their day-to-day life (Bayram & Bilgel 2008). Epidemiological data from around the world suggest a high prevalence of depression and anxiety in this population with 12%-50% meeting criteria for at least one common psychological disorders (Bayram & Bilgel 2008; Bruffaerts et al.). Insufficient PA and high level of SB are also common in university-based young adults, and may be associated with poor psychological wellbeing (Feng et al. 2014; Wu et al. 2016; Wu et al. 2015). This study aimed to use one-year prospective data to examine the associations of PA and SB with psychological distress in a university-based sample of young adults in Dhaka City, Bangladesh.

6.1.3 Methods

6.1.3.1 Study design and population

Data are from a one-year prospective study: Wave 1 (September to December 2015) and Wave 2 (October-November 2016). A convenience sample of first, second and third-year students aged 18 to 24 years was recruited from six (three public and three private) universities based in Dhaka City, Bangladesh. The recruitment procedure can be found elsewhere (Uddin et al. 2017). Fourth-year students were not included at Wave 1 as they were unlikely to be available for follow-up.

Data were collected using a self-administered survey, which was administered in English. Completion of Wave 1 survey took approximately 40-45 minutes, with questions about PA, SB, psychological distress, health and lifestyle factors, and socio-demographics. Wave 2 survey was a sub-set of Wave 1 survey including items on PA, SB, and psychological distress; this took about 15-20 minutes to complete.

Ethics approval was from The University of Queensland Behavioural and Social Sciences Ethical Review Committee, Australia. Each participating institution granted approval to conduct the survey in their premises. All the participants provided written informed consent at Wave 1 to participate at both assessment points.

6.1.3.2 Outcome measure - psychological distress

The Kessler Psychological Distress (K6) scale has been shown to be a reliable and validated self-report to assess general psychological health in a community setting (Kessler et al. 2002). The K6 scale, consisting of six items, coded from 0 to 4 (0 = 'none of the time' to 4 = 'all of the time'), asks how frequently in the past four weeks respondents had experienced each of the following commonly occurring symptoms: sadness, nervousness, fidgety, hopelessness, effortfulness and worthlessness. The six items were added to generate a total score (range: 0-24) with high scores representing more distress. An exploratory factor analysis with varimax rotation confirmed the unidimensionality of the scale in the current study with a one-factor solution, which accounted for 59% and 62% of the variance respectively during Wave 1 and Wave 2. Cronbach's alpha for the scale in this study was 0.85 at Wave 1 and 0.82 at Wave 2.

6.1.3.3 Other measures

PA and SB were measured using the Global Physical Activity Questionnaire (GPAQ), which was developed by the World Health Organisation (WHO) for population surveillance in low- and middle-income countries (Bull et al. 2009). Reliability and validity of the GPAQ have been assessed among adults aged ≥18 years in nine countries, including Bangladesh (Bull et al. 2009). It has been used in >100 countries around the world, including Bangladesh, in the STEPwise Approach to Non-communicable Disease Risk-Factor Surveillance (STEPS) program by the WHO (Bull et al. 2009). The current study used the self-administered version, which is a relatively inexpensive method with comparable reliability and validity to the interview administration (Chu et al. 2015). It consists of 15 items on PA and one on SB (Bull et al. 2009).

6.1.3.3.1 Physical activity

The respondents were asked to report the number of days in a week, and the amount of time in a typical day of the week, they spent doing each of moderate and vigorous PA for work and recreation; and moderate PA for walking or cycling for travel. Consistent with the GPAQ data analysis guideline, all activity data were converted to minutes and were multiplied by the corresponding number of days (World Health Organization 2012). Vigorous activity minutes were weighted by two given the higher intensity than moderate activity (World Health Organization 2012). The time spent in vigorous activity (weighted) and moderate activity minutes were summed to obtain total PA, which was then

dichotomised as ‘sufficient PA’ (≥150 minutes/week) and ‘insufficient PA’ (<150 minutes/week). This is consistent with the WHO’s PA recommendations (World Health Organization 2012). As per the GPAQ protocol, four respondents (two at Wave 1 and two at Wave 2) were excluded from the analyses as they provided improbable or out of range PA/SB data during (World Health Organization 2012). This has been described in details elsewhere (Uddin et al. 2017).

6.1.3.3.2 Sedentary behaviour

The GPAQ asks the participant to report total time spent sitting/reclining (excluding sleeping) during a typical day of the week (Bull et al. 2009). As young adults are more sedentary on weekend days than weekdays (Arias-Palencia et al. 2015), the single question was split into two for a typical weekday and weekend day using the same response options. Total sedentary time (mins/day) was derived as:

$$\text{Daily sedentary time (mins)} = [(\text{weekday time} \times 5) + (\text{weekend day time} \times 2)]/2$$

Currently, there is no consensus threshold at which a person to be defined to have high SB. However, sitting for ≥8hrs/day (480 mins/day) has been shown to significantly increase the risk of all-cause mortality (Chau et al. 2015). This value was therefore used in the present study with SB dichotomised as ‘low’ (<480 min/day) and ‘high’, (≥480 min/day). This criterion has also been used in other research in Asian adults (Win et al. 2015).

6.1.3.3.3 Socio-demographics and lifestyle factors

Participants completed survey items to assess: age, gender, height and weight, marital status (married/unmarried), university type (public/private), enrolled program (Science; Humanities; Engineering; and Business), year of study (year 1 to 3), parents’ education level (primary or equivalent; secondary or equivalent; higher-secondary or equivalent; and tertiary or equivalent), mothers’ current occupation (working/non-working), fathers’ current occupation (government or public service; private sector; professional; self-employed/business; and other, which included semi-skilled and unskilled labour, and farmers), monthly gross household income [≤20,000 Bangladeshi Taka (BDT); 20,001-40,000; 40,001-70,000; >70,000], household composition (living alone; with parents; with family members other than parents; with friends/classmates), and housing type (own house/flat with family; rented house/flat with family; university accommodation/hall; shared accommodation with friends/classmates). Body mass index (BMI) was computed from self-reported height and weight, which was used as a continuous variable. Participants

reported on cigarette smoking (non-smoker, past smoker, occasional smoker, regular smoker); alcohol consumption (I never drink, used to drink previously, drink occasionally, drink regularly); dietary behaviour (e.g., number of servings of each of fast food, fresh fruit, vegetables/green salad during last seven days); frequency of consumption of nonalcoholic carbonated beverages during the past seven days (none, 1-2, 3-4, 5-6, 7-9, 10-13, 14+ glass/cans), and if they had a TV in the bedroom (yes/no). Participants were also asked to rate current health (with five response categories collapsed into poor/fair and good/very good/excellent) and the frequency of experiencing sleep difficulties in the past month (with five response categories collapsed into always/often, sometimes, and rarely/never). Poor health and sleep difficulties have been associated with insufficient PA and poor psychological health in previous research (Feng et al. 2014; Hoyt et al. 2012).

6.1.3.4 Statistical analyses

Dichotomous PA (sufficient and insufficient) and SB (high and low) variables were used to create a 2×2 variable of combinations of PA and SB: sufficient PA+low SB; sufficient PA+high SB; insufficient PA+low SB; and insufficient PA+high SB. The outcome variable (K6 score) was normally distributed, hence the Generalized Estimating Equations (GEE) with *Gaussian* family and *identity* link under *exchangeable* correlation structure was used to examine combined effects of PA and SB with the total K6 scores. In this analysis, GEE took into account the non-independence of students' psychological distress nested within two waves. The following potential covariates assessed at Wave 1 were considered as potential confounders: age, gender, marital status, BMI, parental education and occupation, monthly gross household income, household composition, housing type, television (TV) in bedroom, perceived health, sleep difficulties, smoking, alcohol consumption, fast food intake, fresh fruit and vegetable intake, nonalcoholic carbonated beverage intake, university type, enrolled program, and year of study. Potential confounding variables which had univariate associations with the K6 score at $p<.20$ [as recommended elsewhere (Maldonado & Greenland 1993)] were identified and examined for collinearity. BMI, mother's education, father's occupation, household composition and housing type were initially considered in the multivariable model, but were not significantly associated with the K6 score in the multivariable model and were excluded. Gender, sleep difficulties, perceived health, fast food and fresh fruit intake were significantly associated with the K6 score in the final multivariable GEE model.

A number of sensitivity analysis were conducted: a) unlike PA, there is no established cut-off value for high SB. Hence, three different cut-offs were used to define high SB (≥ 420 min/day, ≥ 540 min/day, and ≥ 600 min/day) to examine the impact of categorisation on results; b) a complete case analysis with only completers those provided valid data during both assessment waves was run to examine possible bias from dropouts; and c) the associations were examined using multilevel generalised structural equation modelling (SEM) to see if such modelling changed the results. Multilevel generalised SEM took into account the nesting of the participants across the two waves.

Outliers and other assumptions of the models were checked and model fit was assessed before finalising the models. The associations are presented in the form of regression coefficients with their 95% confidence intervals. All analyses were performed in STATA version 14 (StataCorp LP., College Station, Texas) with statistical significance set at $p<.05$.

6.1.4 Results

Of the 573 students (response rate: 91.6%) who participated in Wave 1 survey, 397 completed the Wave 2 survey (retention rate: 68.6%). Two respondents were excluded as they provided incomplete data – thus, the analytical sample of this study is 395. At baseline, the average age of the participants was 20.7 years (SD=1.35) and 45% were female. Table 6.1.1 summarises the baseline characteristics of the participants.

The sociodemographic characteristics of Wave 2 respondents were comparable to Wave 1 participants for gender (females 45% vs 48% during Wave 1 and Wave 2, respectively), BMI (21.6±3.3 kg/m^2 vs 22.1±2.9 kg/m^2), being single (94% vs 92%), living with parents (47% vs 52%) and type of university (public 48% vs 42%).

Table 6.1. 1: Baseline characteristics of the participating university-based young adults in Dhaka City, Bangladesh (N=573), 2015

Characteristics		n¥	%
Age (years)			
	Mean 20.7 (SD =1.35)	-	-
Gender			
	Male	313	54.6
	Female	260	45.4
BMI (kg/m^2)			
	Normal range	353	61.7
	Underweight	139	24.3
	Overweight	80	14.0
University type			
	Public	277	48.3
	Private	296	51.7
Year of study			
	First year	184	32.1
	Second year	223	38.9
	Third year	166	29.0
Mother's educational qualification			
	Primary or equivalent	111	19.4
	Secondary (or equivalent)	147	25.7
	Higher secondary (or equivalent)	125	21.9
	Tertiary (or equivalent)	188	32.9
Father's educational qualification			
	Primary or equivalent	53	9.3
	Secondary (or equivalent)	64	11.2
	Higher secondary (or equivalent)	102	17.9
	Tertiary (or equivalent)	352	61.7
Monthly gross family income (in BDT)*			
	≤20,000	115	20.3
	20,001-40,000	162	28.6
	40,001-70,000	172	30.4
	>70,000	117	20.7
Household composition			
	Living alone	24	4.2
	Living with parents	270	47.2
	Living with family members other than parents	46	8.4
	Living with friends/classmates	232	40.6
Housing type			
	Own house/flat with family	181	31.6
	Rented house/flat with family	176	30.7
	University accommodation/hall	146	25.5
	Shared accommodation with friends/classmates	70	12.2

¥Total for each variable may not be equal to n=573 due to missing values
*BDT = Bangladeshi Taka (local currency), 10,000 BDT = 120.5 USD as of 22 Mar. 2018

After adjusting for gender, sleep difficulties, perceived health, fast food and fresh fruit intake, GEE modelling showed that participants with insufficient PA+high SB had a significantly higher level of psychological distress than those who had sufficient PA+low SB [adjusted ß: 3.07, 95% CI: 2.12-4.01, p<.001]. Participants who had insufficient PA+low SB also reported more psychological distress than young adults did with sufficient PA+low SB [2.77 (1.90-3.71), p<.001] after adjusting for the confounders. There was no statistically significant difference for the level of psychological distress between participants with sufficient PA+high SB, and those with sufficient PA+low SB (p=.362) (Table 6.1.2).

Table 6.1. 2: Associations of physical activity and sedentary behaviour with psychological distress scores of university-based young adults in Dhaka City, Bangladesh (N=395), 2015/16†

PA and SB categorise	***Unadjusted estimates***		***Adjusted estimates****	
	ß (95% CI)	*p-value*	ß (95% CI)	*p-value*
Sufficient PA + low SB	Reference		Reference	
Sufficient PA + high SB	-0.67 (-2.00 to 0.66)	.322	-0.59 (-1.86 to 0.68)	.362
Insufficient PA + low SB	3.42 (2.51 to 4.34)	**<.001**	2.77 (1.86 to 3.67)	**<.001**
Insufficient PA + high SB	3.92 (2.97 to 4.86)	**<.001**	3.07 (2.12-4.01)	**<.001**

Values in bold indicate p-value of 0.05 or lower.
†Estimates are based on Generalized Estimating Equations (GEE) with the K6 psychological distress scores as dependent variable
*Adjusted for gender, sleep difficulties, perceived health, frequency of fast food and fresh fruit consumption
Abbreviations: CI = confidence intervals; PA = physical activity; SB = sedentary behaviour

Additionally, there was no statistically significant difference for the level of psychological distress between participants with insufficient PA+high SB, and those with insufficient PA+low SB (p=.336). However, compared to sufficient PA+high SB, participants with insufficient PA+high SB [3.66 (2.50-4.81); p<.001], and insufficient PA+low SB [3.36 (2.23-4.48); p<.001] had a higher level of psychological distress (results are not shown in the table) after adjusting for the confounders. High SB was not

independently associated with psychological distress (p=.638) after adjusting for the same set of confounders (results are not shown in the table).

Results from the sensitivity analysis on GEE platform using different cut-off values for SB did not change the overall results, which suggests that SB categorisation did not affect the results. Findings of the complete case analysis with those provided data on both assessment points did not influence the results; and therefore suggests that findings are not influenced by dropouts. Findings of the multilevel generalised SEM did not change the results suggesting stability of the findings across different modelling platforms.

6.1.5 Discussion

The main finding of this one-year prospective study is that insufficient PA (i.e., >150 mins/week) was associated with high psychological distress irrespective of SB, after controlling for a set of potential confounders. Findings suggest that insufficient PA and high SB increased psychological distress significantly compared to sufficient PA and low SB in the study participants. This is understandable given other research indicating the deleterious effects of each of low PA and high SB (Al-Eisa et al. 2014; Edwards & Loprinzi 2016; Ghorbani et al. 2014; Li et al. 2015; Ströhle 2009; Wu et al. 2016). Insufficient PA and low SB also significantly increased psychological distress, which is also consistent with an expected adverse impact of low PA. However, there were no significant differences in distress between sufficient PA and high SB, and sufficient PA and low SB. This is inconsistent with other research demonstrating adverse effects of high SB (Wu et al. 2016) and suggests that PA may provide protective effects or have a stronger association with psychological health than SB.

Our findings are consistent with a previous cross-sectional study with adolescents that reported insufficient PA increased depressive symptomology, though the combination of insufficient PA and high SB did not (Kremer et al. 2014). These findings, however, are inconsistent with previous cross-sectional studies reporting higher odds of anxiety, depression and other psychopathological problems in university students with high SB and insufficient PA than those with low SB and sufficient PA (Feng et al. 2014; Wu et al. 2016). The inconsistency may be due to the different measures used to examine the relationships. For example, the study in Chinese college students which found that students with insufficient PA and high SB had poorer psychological health than those who

had sufficient PA and low SB used the Self-rating Anxiety Scale, Centre for Epidemiologic Studies Depression Scale and Multidimensional Sub-health Questionnaire for Adolescents (Wu et al. 2015), and this study used a brief composite measure of general psychological distress. The other study used frequency of participation as a measure of PA (Wu et al. 2015), whereas this study used time spent in PA. Sedentary behaviour was assessed as time spent using a computer and watching TV/video in the other study (Wu et al. 2015) and a global measure of time spent sitting/reclining that could have included behaviours other than screen time was used in this current study. A recent meta-analysis of 101 studies found no relationship between video gaming and psychological health problems in youth (Ferguson 2015). Thus, it is possible that not all types of SB are associated with poor psychological health, and that the association depends on the contexts of SB. Future research could examine how different types of SB might interact with PA to influence the psychological health of young adults.

Findings of this study suggest that insufficient PA has significant negative effects on psychological health of university-based young adults, regardless of SB. The underlying mechanism by which PA influences psychological health may involve biological, psychosocial, and/or common cause mechanisms (Stavrakakis et al. 2012). Regular PA has a beneficial effect on the hypothalamic-pituitary-adrenal (HPA) system. Dysregulation of the HPA-axis and hypersecretion of cortisol may have an adverse effect on psychological health (Hamer 2012). PA may act as a moderator to activate the limbic system and reduce cortisol secretion level (Nabkasorn et al. 2006). Insufficient PA may interfere with the HPA functioning system, change serum cortisol level, and cause psychological distress. Dysregulation of the HPA system and sympathetic adrenal medullary, which is caused by insufficient PA may also be responsible for the cardiometabolic syndrome (Goldbacher & Matthews 2007) and increase metabolic disease risk (Wijndaele et al. 2010), which have been linked to poor psychological health (Goldbacher & Matthews 2007). It is also plausible that insufficient PA may interfere with a number of growth factors such as brain-derived neurotrophins and insulin-like growth factor, which are enhanced by exercise, and offer therapeutic and protective effects against depression (Hamer 2012). PA may augment brain aminergic synaptic transmission of monoamines such as norepinephrine, dopamine and serotonin and may also activate β-endorphin secretion, which may subsequently improve psychological health (Paluska & Schwenk 2000).

Psychosocial factors may also explain the relationship. Regular PA may promote self-esteem, a positive body image and health perceptions (Korn et al. 2013), increase social support, positive emotions (Hogan et al. 2015) and overall life satisfaction (Rangul et al. 2012). Insufficient PA may have a negative impact on psychosocial resources such as social support and purpose in life (Hogan et al. 2015), and may increase depression and anxiety (Martinsen 2008; Teychenne et al. 2017).

It is possible that the relationship between poor psychological health and PA is bidirectional (Gunnell et al. 2016). To explore the possibility of bi-directionality, additional modelling was conducted considering each of PA and SB as dependent variable and K6 scores as an independent variable. The results demonstrated that psychological distress was significantly associated with insufficient PA; however, the association was not significant with SB (results not presented). While insufficient PA may have an adverse effect on psychological health, it is also possible that poor psychological health negatively influences PA participation (Gunnell et al. 2016; Stavrakakis et al. 2012). For example, depression may negatively influence PA through a range of affective symptoms such as low mood and sadness, anhedonia, and low self-esteem, and somatic symptoms such as lethargy (Stavrakakis et al. 2012).

The relationship between insufficient PA and poor psychological health may also be explained by common cause hypothesis (Stavrakakis et al. 2012). For example, insufficient PA and depression may share a range of factors including genetic makeup, socioeconomic status, the neighbourhood where an individual resides and parenteral rearing style (Stavrakakis et al. 2012; Stubbe et al. 2007), which may influence both PA and psychological health. It is possible that PA participants are, in general, more satisfied with their lives and are happier than non-PA participants (Stubbe et al. 2007).

To our knowledge, this is the first study that examined the combined effects of PA and SB on psychological health in young adults using prospective data. This study used PA and SB measures, which have been validated in Bangladeshi adults, and adjusted the relationships for multiple covariates including sleep difficulties and subjective health of the participants to minimise possible confounding. A moderately large, heterogeneous sample of students from both public and private universities with a balanced representation of both sexes was used. This study followed-up the participants over one year with two assessment points, which did not allow examination of how the effect(s) of PA and SB on psychological health evolves over the long term. Self-reported measures were used to

assess PA, SB and psychological distress, which are vulnerable to social desirability and recall bias. Though the K6 scale has good reliability and validity in other countries, it has not been validated in a Bangladeshi population. As a non-random convenience sample of university students from a metropolitan city was used, findings may have limited generalisability, and may not be transferable to all young adults.

6.1.6 Conclusions

In this one-year prospective study, insufficient PA was associated with high psychological distress irrespective of SB in a university-based young adult population in Dhaka City, Bangladesh. Our findings reinforce the importance of PA participation during young adulthood to mitigate possible psychological health risks. Our study findings do not suggest any unique combined effect of insufficient PA and low SB on the psychological health of young adults in urban Bangladesh. More long-term prospective studies are needed to further investigate the independent and interactive effects of PA and different types of SB on psychological health to advance our current understanding of these relationships.

6.2 Physical inactivity and sedentary behaviour and sleep difficulties

This manuscript is currently *under review*. The title (with authors) as follows:

Uddin R, Burton NW, Khan A. Effects of physical inactivity and sedentary behaviour on sleep difficulties among young adults: A one-year prospective study.

6.2.1 Abstract

Background: Emerging cross-sectional evidence suggests that insufficient physical activity (PA) and prolonged sedentary behaviour (SB) are independently and in combination associated with poor sleep. The aim of this study was to examine the independent and combined effects of PA and SB on sleep difficulties among university-based young adults using prospective data.

Methods: During 2015 and 2016, 573 undergraduate students from six universities in Dhaka, Bangladesh (Wave 1: average age 20.7±1.35 years; female 45%) completed a self-administered survey on PA, SB and sleep difficulties at two points one-year apart (69% retention). Frequency of sleep difficulties was assessed using a single question with three response categories (rarely, sometimes and often). The Global Physical Activity Questionnaire was used to assess PA and SB.

Results: Insufficient PA was defined as <150 minutes/week of moderate-to-vigorous PA and high SB was defined as ≥480 minutes/day. Generalized Linear Latent and Mixed Models was used to estimate the associations. Participants with insufficient PA had twice the odds of often experiencing sleep difficulties than their counterparts with sufficient PA (OR: 2.21, 95% CI: 1.35-3.61), after controlling for a set of covariates and SB. Participants with insufficient PA+high SB had higher odds of often experiencing sleep difficulties than those with sufficient PA+low SB [OR: 2.52 (1.36-4.64)], after adjusting for the same covariates.

Conclusions: The findings of our one-year prospective study suggest that insufficient PA was independently, and in combination with high SB, associated with sleep difficulties. PA may be an effective non-clinical management strategy to improve sleep among young adults.

6.2.2 Introduction

Sleep is a complex physiological and behavioural process that is important for physical and psychosocial health throughout life (Irwin 2015). Sleep of sufficient duration and quality is essential to maintain optimal health (Colten & Altevogt 2006; Irwin 2015). Poor sleep has been inversely associated with psychological health, and can precipitate depression, anxiety and stress (Colten & Altevogt 2006; Irwin 2015; Zochil & Thorsteinsson 2017). Sleep difficulties have been positively associated with weight gain and obesity, type 2 diabetes, hormonal and other cardiometabolic disorders (Itani et al. 2017; Xi et al. 2014). Given that sleep difficulties have significant negative impact on physical and psychosocial health (Yang et al. 2016), it is important to understand contributing and ameliorating factors (Chau 2015; Colten & Altevogt 2006).

Physical activity (PA) participation is considered as a component of good sleep hygiene (Chennaoui et al. 2015), with previous research demonstrating that regular PA is beneficial for sleep and can improve sleep quality (Chennaoui et al. 2015; Kredlow et al. 2015; Lang et al. 2016). PA participation is associated with better psychological health (such as reduced symptoms of depression, anxiety and stress, improved mood and emotional wellbeing), which also has a significant positive impact on sleep quality (Chennaoui et al. 2015; Loprinzi & Cardinal 2011; Meerlo et al. 2015; Perogamvros & Schwartz 2013). PA is often recommended as a non-pharmacologic therapy for people with sleep difficulties (Atkinson & Davenne 2007; Chennaoui et al. 2015). Sedentary behaviour (SB) such as prolonged screen time, in contrast, may displace sleep time, causing insufficient sleep during the night and fatigue during the day (Weaver et al. 2010). A recent meta-analysis of 16 studies, which included four longitudinal and 12 cross-sectional studies with adults aged ≥18 years, reported that prolonged SB can increase the risk of sleep problems such as insomnia and sleep disturbance (Yang et al. 2016). Participation in regular PA and low levels of SB can be an effective management strategy to help people with sleep problems, in particular those with non-clinical conditions (Hartescu et al. 2015; Yang et al. 2016; Youngstedt 2005).

Young adulthood is considered as one of the most sleep-deprived age groups (Feng et al. 2014). As observed around the world, poor sleep quality may be particularly problematic among university-based young adults who endure many psychosocial challenges such as academic and additional social demands (Bayram & Bilgel 2008; Haile et al. 2017; Lund et al. 2010; Vélez et al. 2013). University-based young adults typically

have insufficient sleep duration, poor sleep quality and more sleep difficulties (Haile et al. 2017; Lund et al. 2010; Vélez et al. 2013). Poor sleep quality among university-based young adults can be associated with prolonged time spent in SB and insufficient PA participation (Feng et al. 2014; Wu et al. 2015). For example, a study with Chinese college students (aged 19.22±1.41 years) found that participants who spent >2 hours/day in screen-based activities were 40% more likely to report poor sleep quality than participants who spent ≤2 hours/day (Wu et al. 2015). Another study with Chinese college freshmen (aged 18.9±0.9 years) reported that students with high PA (≥30 minutes/day of sports or vigorous free play for ≥3days a week) had half the odds of having poor sleep quality (Feng et al. 2014). Evidence from cross-sectional studies with university students also suggests that regular PA and low SB may operate synergistically and improve sleep quality (Feng et al. 2014; Wu et al. 2015). For example, Chinese college freshmen with high PA and low screen-time (e.g., computer/TV-time) were 50% less likely to have poor sleep than those who had low PA and high SB (Feng et al. 2014). Thus, regular PA and low levels of SB are inversely associated with sleep problems among university-based young adults.

Though independent behavioural constructs, PA and SB are parts of the 24-hour time-use continuum, and can interact with each other (Pedišić et al. 2017). Most of the studies that examined the independent effects of PA on sleep difficulties among young adults, however, have not accounted for potentially confounding effects of SB (Feng et al. 2014; Wu et al. 2015). Similarly, most of the studies that examined independent effects of SB have not adjusted the associations for PA (Feng et al. 2014; Wu et al. 2015). The studies that examined the combined effects of PA and SB with sleep difficulties among young adults focussed on computer/TV-time (Feng et al. 2014; Wu et al. 2015), which is one type of SB. The potential impact of SB generally, is therefore, unclear. Moreover, previous studies are cross-sectional in design and only provide limited evidence of a possible association.

To expand our understanding of the effects of PA and SB on sleep difficulties, in this study we aimed to examine the independent and combined effects of PA and SB on sleep difficulties among university-based young adults in Dhaka City, Bangladesh. We hypothesised that young adults with i) insufficient PA would report more frequent sleep difficulties than those who were sufficiently active; ii) high SB would report more frequent sleep difficulties than those with low SB, and iii) insufficient PA + high SB would report more frequent sleep difficulties than those with sufficient PA + low SB.

6.2.3 Methods

Data were from a one-year prospective study with two assessment points one year apart: Wave 1 (September-December 2015) and Wave 2 (October-November 2016) in Dhaka, Bangladesh. A self-administered written survey was used, which included questions about sleep difficulties, PA, SB, lifestyle factors and socio-demographics. The survey was in English. A small pilot study with 30 students (50% female) indicated that the participants had no problem with understanding and completing the English language survey. Wave 1 participants completed the survey in approximately 40-45 minutes. The Wave 2 survey was a subset of the Wave 1 survey and included the same items on PA, SB, and sleep difficulties, which took about 15-20 minutes to complete.

6.2.3.1 Participants

This study recruited a convenience sample of young adults aged 18-24 years from six (three public and three private) universities in Dhaka, Bangladesh. The detailed recruitment procedure can be found elsewhere (Uddin et al. 2017). During Wave 1, the study recruited first, second and third-year students so as to enable data collection in the following year when the students were in second, third and fourth-year, respectively. As fourth-year students were unlikely to be available for follow-up they were excluded at Wave 1. All the participants provided written informed consent at Wave 1 to participate in both waves.

6.2.3.2 Outcome measure - sleep difficulties

The survey asked the participants to respond to the question: ‘During the past month, how often did you experience sleep difficulties?’ with response options of ‘never,’ ‘rarely,’ ‘sometimes,’ ‘often’ and ‘almost always’. Because of skewed distribution of the outcome of interest, and to facilitate interpretable results, we collapsed these responses into three difficulty categories: i) rarely (never+rarely); ii) sometimes and iii) often (often+almost always). A similar approach has been used in previous large-scale research (Rayward et al. 2017).

6.2.3.3 Other measures

PA and SB were measured using the GPAQ, which was developed by the World Health Organization (WHO) for population-level surveillance of PA in resource-limited countries (Bull et al. 2009). A nine-country study including Bangladesh found it to be reliable and valid to assess PA and SB among adults aged ≥18 years (Bull et al. 2009). For logistical reasons, the present study used the GPAQ self-administered version, which is relatively inexpensive method with comparable reliability and validity to the interview administration (Chu et al. 2015). The GPAQ consists of a total 16 items: 15 on PA and one on SB (Bull et al. 2009).

6.2.3.3.1 Physical activity

Participants reported the number of days in a week and amount of time they spent in a typical day of the week doing each of moderate and vigorous PA for work and for leisure, and moderate PA for transport. Activity data were converted to minutes and multiplied by the corresponding number of days. A composite measure of total PA was obtained by summing vigorous- (weighted by two) and moderate-activity minutes. This has been described in detail elsewhere (Uddin et al. 2017). Total PA was dichotomised as 'sufficient' and 'insufficient' using criteria of ≥150 minutes/week and <150 minutes/week, respectively. This is consistent with the WHO's PA recommendations (World Health Organization 2012).

6.2.3.3.2 Sedentary behaviour

Within the GPAQ protocol, participants respond to a single item about total time spent sitting or reclining during waking hours of a typical day of the week (Bull et al. 2009). As young adults are more sedentary on weekend days than weekdays (Arias-Palencia et al. 2015), the study split the single GPAQ question on SB into two sub-questions for a typical weekday and weekend day using the same wording and response options. Total daily sedentary time in minutes as computed as:

$$\text{Daily sedentary time (mins)} = [(\text{Weekday time} \times 5) + (\text{Weekend day time} \times 2)]/7$$

SB was dichotomised as 'low' or 'high', based on the criteria of <480 min/day and ≥480 min/day, respectively. Sitting for ≥480 mins/day (8 hrs/day) has been shown to increase the risk of all-cause mortality significantly (Chau et al. 2015). This approach is consistent with other research in Asian adults (Win et al. 2015).

6.2.3.3.3 Socio-demographics and lifestyle factors

Participants also completed survey items to assess: age, gender, marital status, university type, enrolled program, year of study, parents' education level, mothers' occupation status, fathers' current occupation, monthly gross household income, household composition and housing type. We computed body mass index (BMI) from self-reported height and weight and used this as a continuous variable. Participants reported about cigarette smoking; alcohol consumption; dietary behaviour (e.g., number of servings of each of fast food, fresh fruit, vegetables/ green salad during last seven days); frequency of consumption of nonalcoholic carbonated beverages during past seven days, and if they had a TV in the bedroom.

6.2.3.4 Statistical analyses

Four categories of PA and SB were created to examine the combined effects of PA and SB on sleep difficulties. The categories were: i) sufficient PA+low SB; ii) sufficient PA+high SB; iii) insufficient PA+low SB; and iv) insufficient PA+high SB. The outcome variable in this study (sleep difficulties) had three categories and was assessed at two time points. Hence, Generalized Linear Latent and Mixed Models (GLLAMM) with binomial family and mlogit link was used to examine the associations of PA and SB with sleep difficulties. GLLAMM is a class of multilevel latent variable models for repeated responses. It measures the longitudinal/ prospective associations between the repeated measures by taking into account between-subject heterogeneity and within-subject correlations. Each additional period of data is not independent of the previous periods, and as such the standard error of the model estimators are adjusted for within-subject variability. This type of analysis controls for unobserved or unmeasurable sources of individual heterogeneity that vary across individuals but do not vary over time. Added advantages of GLLAMM includes handling of missing data. By adding additional information, GLLAMM offers more accurate inference of model parameters. In the present study, GLLAMM used all available information (from both waves) and took into account the non-independence of sleep difficulties nested within the two waves, adjusted for other factors. To ensure reliable estimates from the modelling, we used a 10-point numerical integration with adaptive quadrature (Rabe-Hesketh et al. 2002).

The following variables assessed during Wave 1 were considered as potential confounders in the modelling: age, gender, marital status, BMI, parental education and occupation, monthly gross household income, household composition, housing type,

university type, enrolled program, and year of study, TV in bedroom, smoking, alcohol consumption, fast food intake, fresh fruit and vegetable intake, non-alcoholic carbonated beverage intake (Adams & Colner 2008; Bartel et al. 2015). The potential confounding variables which had univariate associations with sleep difficulties at p<.20 [as used elsewhere (Maldonado & Greenland 1993)] were identified. Variables significantly associated with sleep difficulty at the bivariate level were examined for collinearity. As in this modelling, the outcome variable 'sleep difficulty' had three categories (rarely, sometime and often); it involved the estimation of following two equations:

i) The likelihood of experiencing sleep difficulties sometimes vs the likelihood of experiencing sleep difficulties rarely, and
ii) The likelihood of experiencing sleep difficulties often vs the likelihood of experiencing sleep difficulties rarely.

The GLLAMM provided estimates of odds ratios (OR) with their 95% confidence intervals (CI) for the independent associations of sleep difficulties with PA, SB, and the combined associations with four PA and SB categories after adjusting for a set of confounders. To examine the independent associations of sleep difficulties with PA, additional adjustment with SB was performed, and for independent associations with SB, PA was included in the model. We conducted reverse analyses (GLLAMM with binomial family and logit link) with sleep difficulty as an independent variable, each of PA and SB as a dependent variable, and adjusted each of the relationships for their respective set of covariates.

We conducted a number of sensitivity analyses: (a) Unlike PA, there is no consensus cut-off value to define high SB. Therefore, we used three different cut-offs for high SB (≥7 hrs/day, ≥9 hrs/day, and ≥10 hrs/day) to examine the impact on results; (b) The dichotomised PA and SB categories were replaced by continuous data to establish whether dichotomising had any effect on results; (c) We also ran a complete case analysis with only completers on a nested sample of participants who provided valid data on both assessment points to examine possible bias from dropouts; (d) We examined the associations using multilevel generalised structural equation model (SEM) to see whether such modelling changed the conclusions. Multilevel generalised SEM took into account the nesting of the participants across two assessment waves. All analyses were performed in STATA version 14 (StataCorp LP., College Station, Texas) with statistical significance set at p<.05.

6.2.4 Results

6.2.4.1 Participants

Of the 628 students invited, 575 completed the Wave 1 survey (response rate: 92%, average age: 20.7±1.35 years, female: 45%). Data for two respondents were excluded as they provided incomplete/ out-of-range data on PA/SB. This has been described in detail elsewhere (Uddin et al. 2017). Of the 573 Wave 1 participants, 397 completed the Wave 2 survey (retention rate of 69%). Due to incomplete data on PA at Wave 2, two respondents were further excluded. Table 6.2.1 summarises the characteristics of the participants at baseline.

Participants in both survey waves had comparable sociodemographic characteristics, including gender (females 45% in Wave 1 vs 48% in Wave 2), being single (94% vs 92%), living with parents (47% vs 52%), university type (public 48% vs 42%), and BMI (21.6±3.3 kg/m^2 vs 22.1±2.9 kg/m^2).

Table 6.2. 1: Characteristics of the participating young adults in Dhaka City, Bangladesh (N=573), 2015.

Characteristics		n¥	%
Gender			
	Male	313	54.6
	Female	260	45.4
BMI (kg/m^2)			
	Healthy weight	353	61.7
	Underweight	139	24.3
	Overweight	80	14.0
University type			
	Public	277	48.3
	Private	296	51.7
Year of study			
	First year	184	32.1
	Second year	223	38.9
	Third year	166	29.0
Mother's educational qualification			
	Primary or equivalent	111	19.4
	Secondary (or equivalent)	147	25.7
	Higher secondary (or equivalent)	125	21.9
	Tertiary (or equivalent)	188	32.9
Father's educational qualification			
	Primary or equivalent	53	9.3
	Secondary (or equivalent)	64	11.2
	Higher secondary (or equivalent)	102	17.9
	Tertiary (or equivalent)	352	61.7
Monthly gross family income (in BDT)*			
	≤20,000	115	20.3
	20,001-40,000	162	28.6
	40,001-70,000	172	30.4
	>70,000	117	20.7
Household composition			
	Living alone	24	4.2
	Living with parents	270	47.2
	Living with family members other than parents	46	8.4
	Living with friends/classmates	232	40.6
Housing type			
	Own house/flat with family	181	31.6
	Rented house/flat with family	176	30.7
	University accommodation/hall	146	25.5
	Shared accommodation with friends/classmates	70	12.2

¥Total for each variable may not be equal to n=573 due to missing values
*10,000 BDT = 118.06 USD as of 8 May 2018

6.2.4.2 Frequency of sleep difficulties and changes over time

At Wave 1, just over one-quarter (28%) of the participants reported experiencing sleep difficulties often and one-quarter (26%) reported sleep difficulties sometimes. Though a similar percentage of participants reported sleep difficulties across the assessment points (Figure 6.2.1), as shown in Figure 6.2.2, the majority of the participants reported a different frequency across the assessment, which suggests that sleep difficulties can be episodic.

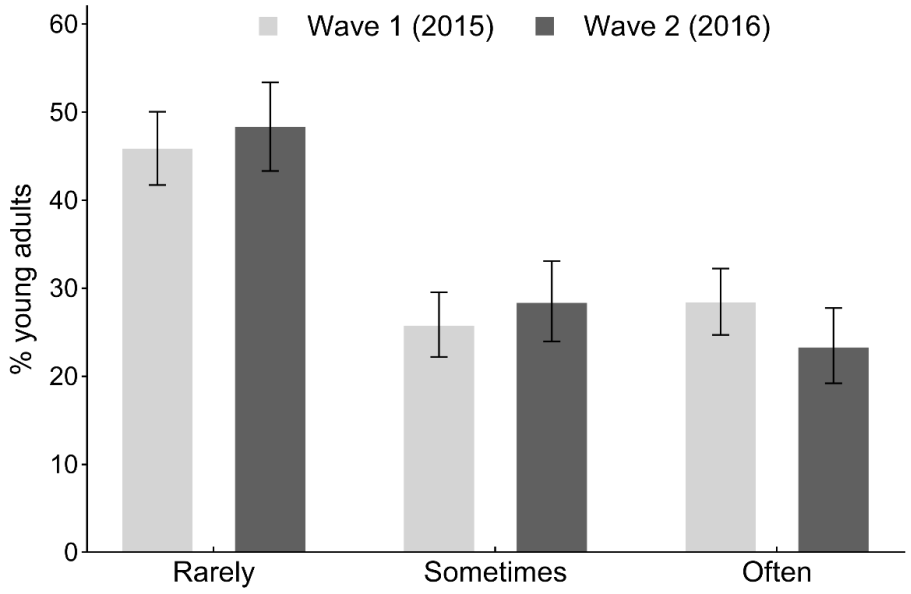

Figure 6.2. 1: Percentage of young adults in Dhaka City, Bangladesh reporting experience of sleep difficulties, by assessment wave (N_{wave1}=573 and N_{wave2}=395).

*Error bars represent 95% CIs

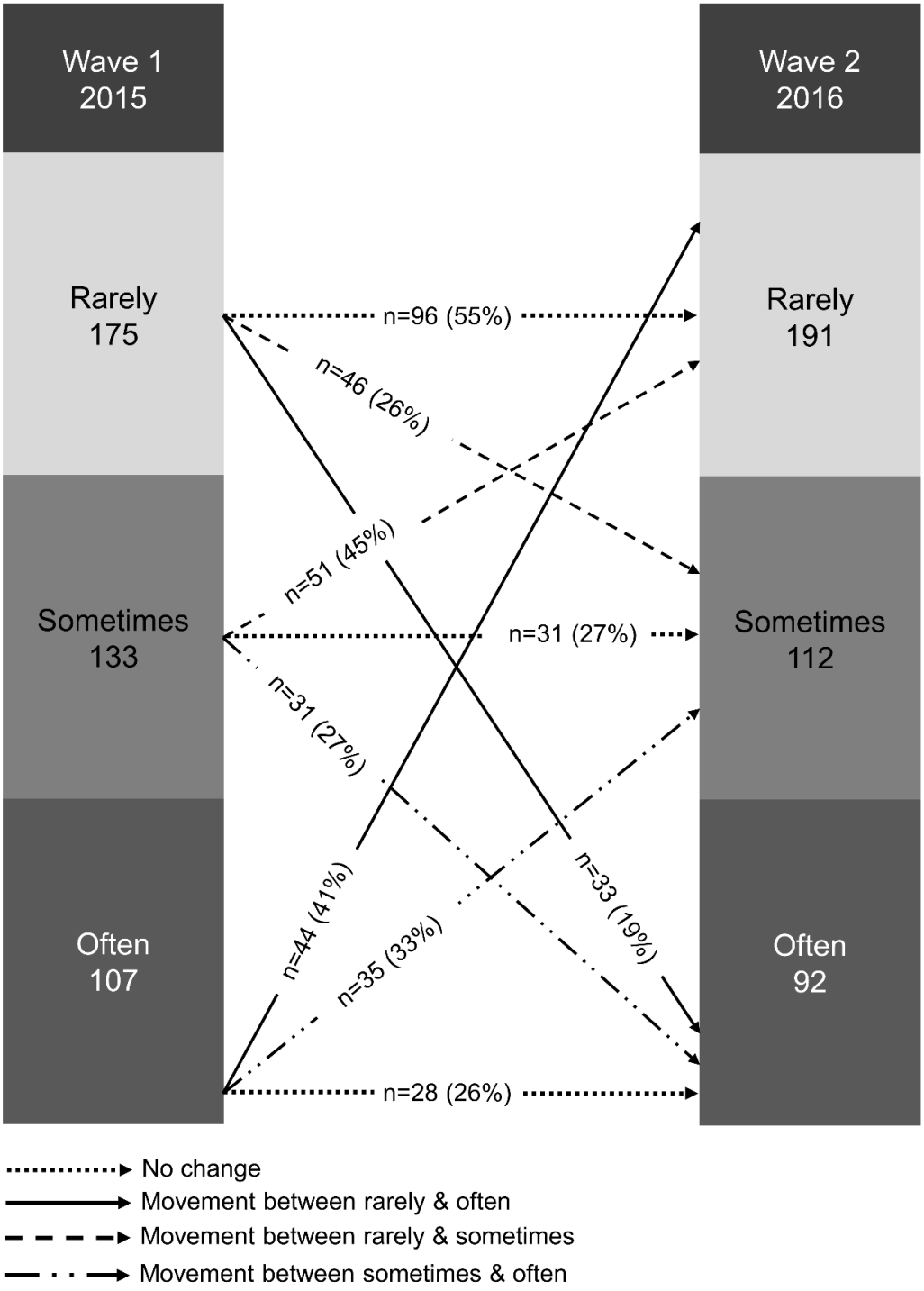

Figure 6.2. 2: Changes in reported sleep difficulty frequency, across the assessment waves, among university-based young adults in Dhaka City, Bangladesh (N=395) †

†Includes only those who participated in both waves

Of the 395 students who participated in both Waves, 175 reported experiencing sleep difficulties rarely at Wave 1, of which about one-quarter (26%) moved to 'sometimes', one-fifth (19%) to 'often' and more than half (55%) remained unchanged at Wave 2. Of those participants who reported having sleep difficulties sometimes at Wave 1, just under half (45%) moved to 'rarely'; 27% moved to 'often' and 27% remained unchanged at Wave 2. Of the 107 participants who reported having sleep difficulties often at Wave 1, two-fifths (41%) and one-third (33%) moved to 'rarely' and 'sometimes' categories, with 26% remained in 'often' category at Wave 2. Figure 6.2.2 illustrates all of these movements across two assessment points.

6.2.4.3 Independent associations of physical activity and sedentary behaviour with sleep difficulties

After adjusting for BMI, cigarette smoking, the frequency of fast food consumption and SB, GLLAMM modelling showed that young adults with insufficient PA had twice the odds of often experiencing sleep difficulties than those with sufficient PA (OR: 2.21, 95% CI: 1.35-3.61). Young adults with high SB had higher odds of sometimes having sleep difficulties than those with low SB after adjusting for the same set of confounders and PA [OR 1.41 (0.99-2.00)], however the evidence for the association is marginal with p=0.068 (Table 6.2.2).

6.2.4.4 Combined associations of physical activity and sedentary behaviour with sleep difficulties

Table 6.2.2 also presents the combined associations of PA and SB with sleep difficulties. Young adults with insufficient PA + high SB had 2.5 times higher odds to report sleep difficulties as often than those with sufficient PA + low SB, after adjusting for BMI, cigarette smoking and the frequency of fast food consumption [OR 2.52 (1.36-4.64)]. There was no statistically significant associations of sleep difficulties with other PA and SB categories (sufficient PA + high SB, and sufficient PA + low SB) when compared with young adults who had sufficient PA + low SB, after adjusting for the same set of confounders.

Table 6.2. 2: Associations of physical activity and sedentary behaviour with frequency of sleep difficulties among young adults in Dhaka City, Bangladesh, 2015/16†.

PA and SB categories	Sleep difficulties			
	Rarely vs. sometimes		Rarely vs. often	
	Adjusted OR* (95% CI)	p-value	Adjusted OR* (95% CI)	p-value
Independent effects				
Sufficient PA	Reference	-	Reference	-
Insufficient PA	1.15 (0.75-1.77)	.523	2.21 (1.35-3.61)	**.002**
Low SB	Reference	-	1	-
High SB	1.41 (0.99-2.00)	.054	1.33 (0.94-1.90)	.111
Combined effects				
Sufficient PA+low SB	Reference	-	Reference	-
Sufficient PA+high SB	1.55 (0.73-3.29)	.252	0.71 (0.27-1.87)	.492
Insufficient PA+low SB	1.22 (0.70-2.12)	.481	1.73 (0.96-3.12)	.068
Insufficient PA+high SB	1.68 (0.94-2.99)	.078	2.52 (1.36-4.64)	**.003**

Values in bold indicate p-value of 0.05 or lower
† Estimates are based on Generalized Linear Latent and Mixed Models (GLLAMM) with self-reported frequency of sleep difficulties as outcome variable
*Adjusted for body mass index, cigarette smoking and frequency of fast food consumption. Additional adjustment with sedentary behaviour and physical activity was done to examine independent effect of physical activity and sedentary behaviour, respectively
Abbreviations: OR=odds ratio; CI=confidence intervals; PA=physical activity; SB=sedentary behaviour

In a reverse analysis using GLLAMM (adjusted for gender, fresh fruit consumption, and participation in organised sports), participants who often experienced sleep difficulties had more than twice the odds [2.67 (1.19-5.96); p=.017] of being insufficiently active, suggesting a bidirectional relationship between PA and sleep difficulties. Sleep difficulty, however, was not significantly associated with SB [1.37 (0.93-2.02].

Results from the sensitivity analyses using different cut-off values for high SB, and continuous PA and SB values did not change the results suggesting stability of the results. Findings of the complete case analysis with data from those participated in both waves did not influence conclusions, suggesting that findings were not driven by dropouts. Findings of the generalized SEM did not change the conclusions; however, the analysis suggested a significant association between insufficient PA + low SB with having sleep difficulties often (p=.038). There was also marginal evidence to suggest that insufficient PA + high SB was associated with having sleep difficulties sometimes (p=.049).

6.2.5 Discussion

The main finding of this one-year prospective study is that among university-based young adults, insufficient PA (i.e., <150 mins/week) independently and in combination with low

SB (i.e., <480 mins/day) was associated with often experiencing sleep difficulties, after adjusting for a set of covariates. However, low SB was not independently associated with often experiencing sleep difficulties. Findings of this study are consistent with previous cross-sectional studies among young adults that have reported combined effects of insufficient PA and low SB on quality of sleep as measured by Pittsburgh Sleep Quality Index (Feng et al. 2014; Wu et al. 2015). The independent association between insufficient PA and sleep difficulties found in this study is, broadly, consistent with previous intervention (Kalak et al. 2012) and cross-sectional studies (Feng et al. 2014) on sleep quality of young adults. The finding that low SB was not independently associated with sleep difficulties is consistent with a cross-sectional study with Chinese college students (Feng et al. 2014); however, a previous cross-sectional study with another similar Chinese student cohort did not find such associations (Wu et al. 2015). Both of these previous cross-sectional studies used the same measures and definition for high SB (>2 hours/day of computer/TV time) and sleep quality (Pittsburgh Sleep Quality Index) as each other. However, the current study used a more broad measure of SB that was not limited to screen time, and a basic single-item measure of sleep difficulties. Hence, further prospective studies are required to understand how different types of SB may independently affect sleep among young adults.

The findings of this study may have clinical relevance. Usual treatment options for sleep difficulties include the use of medicines (such as benzodiazepines) and cognitive behavioural therapy (CBT) (Espie et al. 2001). While both these approaches have proven effectiveness, drug treatment has a number of adverse effects such as increased fatigue, impaired cognitive performance and daytime function, reversible dementia, drug dependency and withdrawal symptoms and therefore is not recommended in the long-term (Kripke 2000; Youngstedt 2005). CBT requires specialist training, may not be accessible or affordable, and can be time-consuming (Espie et al. 2001). Incorporating PA in everyday life and having low levels of SB can be a low-to-no cost, safe, effective and sustainable strategy to help people with sleep difficulties, particularly for those who have non-clinical sleep conditions (Hartescu et al. 2015; Yang et al. 2016; Youngstedt 2005). Other research has demonstrated that exercise training can reduce the need of sleep medication (Yang et al. 2012). More research is needed to understand the dose-response effect of PA and SB and how different domains and types of these behaviours are associated with sleep difficulties.

The underlying mechanisms by which PA may influence sleep quality is complex and may include a number of physical (Atkinson & Davenne 2007; Chennaoui et al. 2015) and psychological pathways (Chennaoui et al. 2015; Feng et al. 2014). The concentration of melatonin has been shown to increase during PA (Thrift et al. 2014), and this pineal hormone is associated with thermoregulation (hypothermia) and perhaps prompts better sleep quality (Wyatt et al. 2006). It is possible that regular PA improves sleep quality by creating a more regular *sleep-wake-sleep* cycle (Foti et al. 2011). Anti-depressant activity of regular PA may act as a mediator to improve sleep quality (Chennaoui et al. 2015; Feng et al. 2014). The association between regular PA and improved sleep quality may be due to the common causes. For example, individuals who participate in regular PA may practice other health-enhancing behaviours such as a healthy diet and low caffeine, which are also associated with improved sleep quality (Drake et al. 2013; Feng et al. 2014).

The relationship between PA and SB with sleep seems to be complex. A reverse analysis with sleep difficulty as an independent variable and each of PA and SB as a dependent variable suggested that the association between PA and sleep difficulties was bidirectional, while there was no statistically significant association between sleep difficulties and SB. Poor sleep quality may hinder PA participation (Kline 2014; Rayward et al. 2017), and can be associated with fatigue and exhaustion that promote SB (Lakerveld et al. 2016). As argued elsewhere, SB may displace time for PA and sleep, and cause sleep difficulties (Wu et al. 2015). There is evidence that poor sleep causes a bidirectional affective imbalance, alters reward and emotional processing in the brain, causes stress, and deteriorates mood and exacerbates depression (Perogamvros & Schwartz 2013). It is therefore possible that when people feel stressed they do not do PA (e.g., feeling too busy to exercise) (Burg et al. 2017) or if not sleeping well they may not have the energy to participate in PA (Herring et al. 2018). Hence, causation may in fact be circular with positive feedbacks loops. Therefore breaking this cycle by facilitating PA may be the means to recovery from or prevention of sleep problems. A better understanding of such associations would have practical clinical significance to counsel patients on benefits of PA.

Strengths of the current study include the prospective design, and measures of PA and SB that have been validated in Bangladeshi adults (Bull et al. 2009). The relationships were adjusted for multiple covariates to minimise possible confounding. To examine independent effects of PA and SB on sleep difficulties, adjustments with SB and PA, respectively, were made, which has not been done in previous cross-sectional studies

(Feng et al. 2014; Wu et al. 2015). The sample for this study was a moderately large and heterogeneous cohort of students with equal representation from both public and private universities. There are several methodological limitations of this study. Self-reported measures, which were used to assess sleep difficulties, PA and SB are vulnerable to social desirability and recall bias, and the measure of sleep difficulties was limited to a single item. Similar measures for sleep difficulties/quality have been used in other large studies (Hui & Grandner 2015; Rayward et al. 2017); however, different aspects of sleep efficiency and sleep onset latency cannot be captured without objective measures. Participants were followed-up over one year with two assessment points, which did not allow us to examine how the effect(s) of PA and SB on sleep difficulties may evolve over the long term. Due to the possible bidirectional nature of the associations, estimation of causal mechanism or pathway is difficult. The findings of our study may have limited generalisability because of the use of a non-random convenience sample of university students from a metropolitan city. Hence, findings may not be transferable to non-university students and young adults in regional areas.

6.2.6 Conclusions

In this study, insufficient PA was independently, and in combination with high SB, associated with frequent sleep difficulties in university-based young adults in urban Bangladesh. Extending previous cross-sectional evidence, our prospective study provides support for PA participation and low levels of sedentary time to promote sleep quality in young adults. To advance our current understanding of the associations between PA and SB with sleep among young adults, long-term population-based prospective studies with more assessment points are needed.

Chapter 7: Discussion

7.1 Overview of research project

The overarching aim of this research was to assess physical activity (PA) and sedentary behaviour (SB), individual level correlates, and associations with psychological wellbeing among young adults aged 18 to 24 years in Bangladesh.

Over recent decades, the burden of non-communicable diseases (NCDs) and NCD-related poor health have increased steadily in young adults aged 20-24 years in Bangladesh (Global Burden of Disease n.d.). Insufficient PA and prolonged SB are important predictors of NCDs in adults (Henson et al. 2016; Lee et al. 2012; Proper et al. 2011; Rhodes et al. 2017), and have also been associated with poor psychological wellbeing (Rhodes et al. 2017; Tremblay et al. 2010). Young adults are more likely to adopt these unhealthy lifestyle behaviours than other age groups (Tucker 2011; Zickuhr 2011), and therefore are at greater risk for NCD-related adverse health consequences. Poor psychological wellbeing is also common among young adults in Bangladesh (Global Burden of Disease n.d.), though an under-recognised issue. mental health and substance use disorders are ranked as the main causes of poor health among those aged 20-24 years in Bangladesh (Global Burden of Disease n.d.).

However, little is known about PA and SB, or their relationships with psychological wellbeing, among Bangladeshi young adults. This is important evidence for population health given that the 15-24 years age-group form one-fifth of Bangladeshi population (United Nations 2016). Such evidence can help to improve health and wellbeing by informing pragmatic intervention strategies.

The specific objectives of this research program were to:

i) determine the prevalence and sociodemographic patterns of PA and SB;
ii) identify individual-level correlates of PA, SB, and changes in PA and SB over one-year; and
iii) examine the associations of PA and SB with psychological distress and sleep difficulties.

To address these objectives, a one-year prospective study with two assessment points was conducted with a convenience sample of university-based young adults in Bangladesh. Findings in relation to specific individual studies have been discussed in the previous sections. This final discussion section will present an overall synthesis in relation to the overarching aim of this research program. Practical implications of the findings will be discussed, as well as strengths and limitations of the research and directions for future research.

7.2 Key findings

7.2.1 Overview of key findings

There was a high prevalence of insufficient PA (<150 mins/week) and prolonged SB (≥480 mins/day) among university-based young adults in urban Bangladesh. There were gender-based patterns of PA and SB. Females spent more time in SB and were more likely to be insufficiently active than males. Males spent significantly more time in PA for transport and recreation than females. Females participated more in indoor activities (e.g., yoga, stationary exercise); and males did more outdoor activities (e.g., cricket, football). Gender-based differences were also found for individual-level correlates of PA. Cross-sectional data suggested that females were more likely than males to perceive a lack of safety as a barrier to PA. One-year prospective data identified PA outcome expectations and increased age as positive correlates of PA for females, but not males. Psychological distress was inversely associated with males', but not females', PA. Of those who participated in both survey waves, 85% maintained their PA status (sufficiently/insufficiently active) over one year, and 59% maintained their SB status (high/low sedentary) over one year, suggesting that SB is more variable than PA. Males, participants with high phone time, those not engaging in organised sports, and those with frequent stress were more at risk of developing an inactive lifestyle. Insufficient PA, but not high SB, was inversely associated with psychological wellbeing, including sleep quality, among university-based young adults in Bangladesh (Figure 7.1).

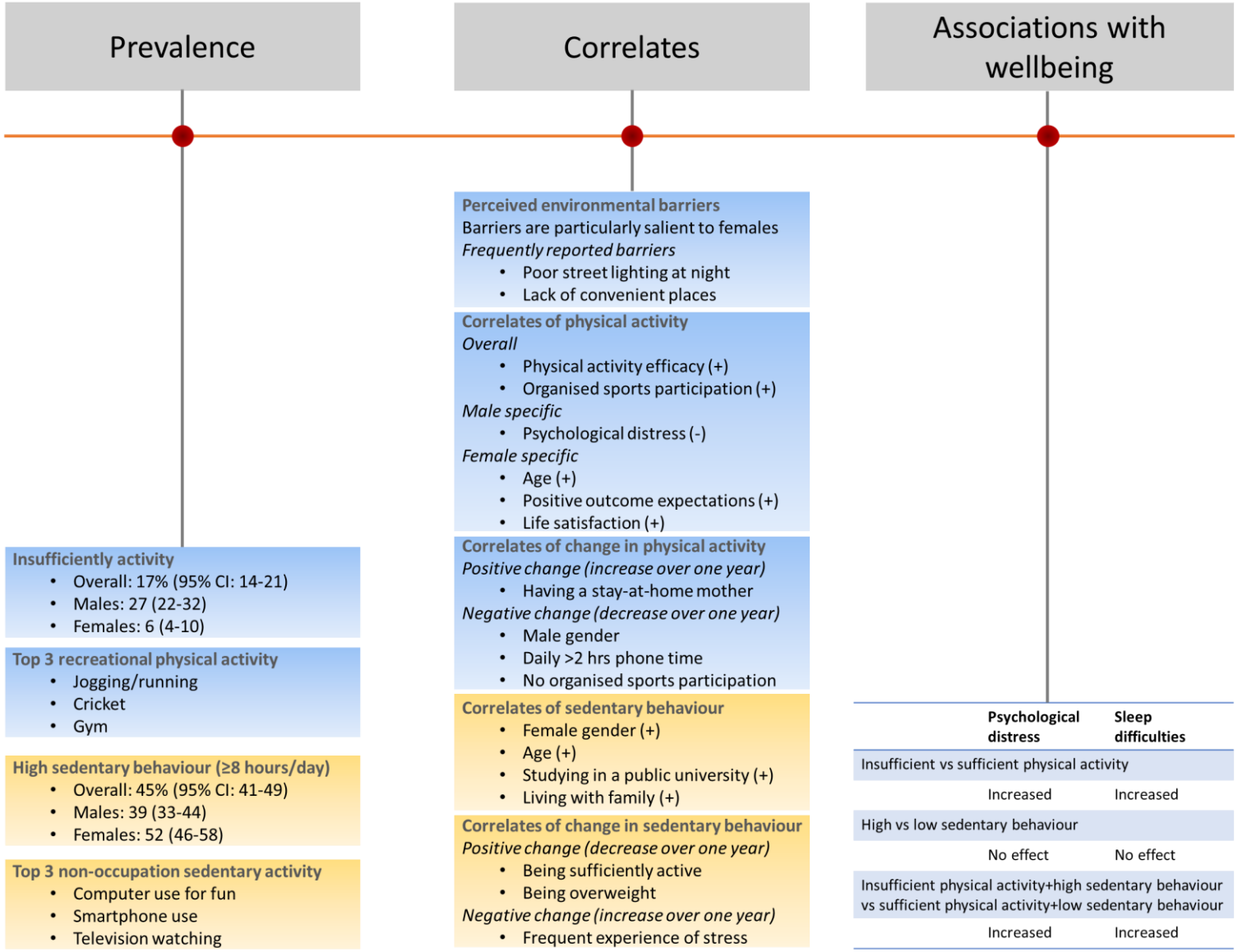

Figure 7. 1: Mapping of overall results

7.2.2 Objective 1: To determine the prevalence and sociodemographic patterns of physical activity and sedentary behaviour.

The prevalence of insufficient PA found in this research (83%) is much higher than a previous study with university students in Bangladesh (41%) (Pengpid et al. 2015). This difference could be attributable to the wider age group (16-30 years) and use of a different measure of PA (the International Physical Activity Questionnaire; IPAQ) in that other study. In the current research, just less than half of the participants (45%) spent >480 mins/day in SB. This is consistent with a recent study with Singaporean young adults (aged 18-29 years) that used the same criterion and reported 48% of participants as having high SB (Win et al. 2015). Findings of the current research that young adults in Bangladesh spend about half of their daily waking time sedentary (median time of 450 mins) is consistent with other studies of young adults in developed countries such as Australia (McVeigh et al. 2016) and the USA (Matthews et al. 2008).

Findings that the prevalence of insufficient PA (<150 mins/week) was significantly higher among females than males is consistent with previous studies of university students across a range of countries, including in the South Asian region (Haase et al. 2004; Pengpid et al. 2015; Yahia et al. 2015). The current research program found gender-based differences in patterns of PA participation. More males (64%) than females (35%) reported leisure-time PA (LTPA) with males [median time of 100 mins/week (IQR: 60-180)] spending significantly more time in LTPA than their female counterparts [80 (60-120), p=.03]. More males reported outdoor LTPA and team-sports such as cricket and football than their female counterparts, and more females reported indoor LTPA such as yoga and stationary exercise. Social norms and gender roles can have a significant negative impact on young adult females' PA participation in Bangladesh. Due to socio-cultural customs in Bangladesh, females may have restricted access to outdoor activities (e.g., cricket, football, cycling) and limited opportunities for LTPA (Goetz 2013; Islam 2013; UNICEF 2010).

Gender-based differences were also observed in SB in the current research program. Female participants reported significantly more television (TV) time during weekend days than their male counterparts did (median time of 180 mins vs. 120 mins; p=.003). While males spent a median time of 60 mins/day in sitting-talking and 30 mins/day in phone conversations during a typical weekend, females spent significantly

more time – 120 mins/day (p<.001) in sitting-talking and 60 mins/day (p=.002) in phone conversations. A similar gender-based difference in these types of activities was observed for a typical weekday. This is inconsistent with a review of studies in developed countries which suggested no gender differences in these type of sedentary pursuits (Rhodes et al. 2012). Due to restricted outdoor access, young females in Bangladesh may spend more time indoors than males; and hence, could be more likely to engage in recreational sedentary pursuits than their male counterparts would. More research is needed to understand context-specific SB among Bangladeshi young adults.

7.2.3 Objective 2: To identify individual-level correlates of physical activity, sedentary behaviour, and changes in physical activity and sedentary behaviour.

Cross-sectional analyses showed that perceived environmental barriers to PA differed by gender. Females were more than four times more likely than males to report an unsafe neighbourhood as a barrier to PA, after adjusting for body mass index (BMI), age, mother's education, father's education, living arrangement and housing type. Other research has indicated that females in Bangladesh often avoid walking as they consider themselves vulnerable to crime (Shumi et al. 2015). A study in Dhaka, Bangladesh reported that three-quarters of female adolescents aged 14-16 years had experienced sexual or street harassment (Airin et al. 2015). Intervention programs could, therefore, consider indoor PA facilities exclusively for females, which may be considered safer than being outdoors in the neighbourhood.

Findings from this research program suggest that participation in organised sports and PA efficacy were positively associated with both males' and females' PA. However, there were gender difference in other PA correlates. Prospective data modelling found that PA outcome expectations and older age were positive correlates of females', but not males' PA, after adjusting for father's occupation, mother's employment status, BMI, SB, psychological distress, social support, and consumption of each of fresh fruits, vegetables and carbonated beverages. PA outcome expectations have been consistently reported as a correlate of PA in the general (Rhodes et al. 2017). The measure of outcome expectations in the current research included improvements in appearance and health, a reduced risk of poor health, and weight management, which may be salient to females. Previous research with university students in the USA has demonstrated that females were more concerned than males with appearance and weight management, and were

more likely to practice a healthier lifestyle (Kilpatrick et al. 2005). This information should be considered when developing PA promotion strategies in Bangladesh either across or by gender.

Prospective data modelling demonstrated that being a female was associated with prolonged SB, after adjusting for BMI, PA, anxiety and sleep difficulties, perceived health, housing type, TV in bedroom and mother's education. Other researchers have concluded that the association between SB and gender is still indeterminate and not well understood among the adult population (Rhodes et al. 2012). Behavioural Choice Theory suggests that during free time, one behaviour competes with another; hence, time spent in one can be affected and subsequently displaced by the other (Rachlin et al. 1980). In this research program, females had significantly less LTPA, especially in the outdoors. It is therefore possible that young adult females' leisure-time that could have been spent in PA was displaced by home-based sedentary activities or screen use. In this research program, living with family was positively associated with SB. When students live with their family they may have less family responsibilities (e.g., household chores), which may create more opportunities for time spent in SB. Accordingly, young adults may have a sense of financial responsibility as they start sharing an accommodation with others (Berngruber 2016), and may need to support their study and engage in paid work (Berngruber 2016), which could create less time for SB. Students who live alone or with others (e.g., friends or colleagues) in shared accommodation may have 'housekeeping' responsibilities such as doing groceries and other household chores, which may leave less time for SB.

Findings suggested that SB was more variable than PA, with more participants maintaining their PA status (85%) than SB status (59%) over one year. Of the participants who had sufficient PA at Wave 1, 5% became insufficiently active at Wave 2. Of those who had low SB at Wave 1, 16% reported high SB at Wave 2. Multivariable modelling suggested that being male, baseline phone time of >2 hrs/day, and not participating in organised sports at baseline were associated with a decrease in PA by >60 mins/week over one year. Frequently experiencing stress at baseline was positively associated with an increase in SB by >120 mins/day. The correlates of a behaviour may not be associated with changes of that behaviour over time (Brug et al. 2005), and not much is known about factors that may be associated with changes in PA and SB among young adults. This current research project provides some information on this aspect of activity behaviours. More research with longer follow-up periods are required to confirm these findings.

7.2.4 Objective 3: To examine the associations of physical activity and sedentary behaviour with psychological distress and sleep difficulties.

Multivariable prospective data modelling showed that insufficient PA was associated with psychological distress among university-based young adults in Bangladesh, irrespective of SB, and after adjusting for gender, perceived health, fast food and fresh fruit intake, and sleep difficulties. Insufficient PA, independently and in combination with low SB, was associated with sleep difficulties, after adjusting for BMI, cigarette smoking and, fast food consumption (for independent effect of PA, SB was included in the model in addition to the other potential confounders). Overall, there was no independent adverse effect of high SB on any of the two measures of psychological wellbeing – psychological distress and sleep difficulties – in this population group. Hence, findings suggest that insufficient PA has a significant inverse association with psychological wellbeing among university-based young adults in Bangladesh. These findings are consistent with previous intervention research with young adults in LMICs (Ghorbani et al. 2014; Li et al. 2015) and high-income countries (Al-Eisa et al. 2014) and longitudinal studies with young adults in high-income countries (Ströhle et al. 2007).

The findings that SB had no significant independent adverse effect on psychological wellbeing is inconsistent with previous studies which suggest that prolonged SB such as screen use can be associated with depression, anxiety and poor sleep quality of young adults (Edwards & Loprinzi 2016; Feng et al. 2014; Wu et al. 2016; Wu et al. 2015). The inconsistency may be due to the different measures used to assess study variables. For example, a study in Chinese college students which reported that students with high SB had poorer psychological health used the Centre for Epidemiologic Studies Depression Scale and Multidimensional Sub-health Questionnaire for Adolescents (Wu et al. 2016), while the current research project used a brief composite measure of general psychological distress (Kessler et al. 2002). In the earlier Chinese study, SB was assessed as recreational screen-time, such as time spent using a computer and watching TV/video (Wu et al. 2016), whereas this current research used a global measure of SB including both occupational and non-occupational sedentary activities rather than just screen-time. A recent meta-analysis of 101 studies found no relationship between video-gaming and poor psychological wellbeing in youth (Ferguson 2015). It is therefore possible that not all types of SB are associated with poor psychological wellbeing, and the association depends on

the contexts of SB. Future research could examine how context specific SB influences the psychological wellbeing of young adults.

PA and SB occur within the 24-hour time use continuum, in individuals (Pedišić et al. 2017); however, the evidence for the combined effects of PA and SB on psychological wellbeing is limited. Consistent with previous cross-sectional studies with university-based young adults in China (Feng et al. 2014; Wu et al. 2015), the combination of insufficient PA and high SB was associated with frequency of sleep difficulties of young adults in this research project. However, the current study findings suggested no unique combined effect of insufficient PA and high SB on psychological distress. This reinforces the importance of PA participation during young adulthood to mitigate possible psychological health risks. Findings also imply that prioritising intervention efforts for promoting PA over SB may be more beneficial for wellbeing among university-based young adults in Bangladesh.

7.3 Limitations of the research

Several methodological limitations relevant to this research need to be acknowledged. Participants of this study were a convenience sample of students from purposively selected universities from Dhaka city, Bangladesh. Only students who were interested in the study would have agreed to take part in the study, which may have provided volunteer bias. University-based young adults may have more sedentary time than who are non-university-based, as study itself is sedentary, at least in a conventional classroom setup. Academic commitments such as attending lectures, study for the next day, and preparing for examinations, may interfere with self-regulation and time management skills of university-based young adults (McArthur & Raedeke 2009), prolong SB for study and reduce discretionary time for PA (Leslie et al. 2001). University students can be stressed with assessments, which can also adversely influence lifestyle behaviours, including PA or SB (Harari et al. 2017; Leslie et al. 2001). The students therefore may have a different level of wellbeing, including stress and sleep behaviour, than other young adults. The participants of this study were based in a large metropolitan city. Young adults in rural or regional Bangladesh may be associated with agriculture or other labour intensive activities, and therefore have a different activity profile than urban young adults. Hence, the findings of this research project may have limited generalisability and are unlikely to represent all young adults in Bangladesh.

Self-reported measures were used to assess PA, SB, wellbeing (distress and sleep difficulties), height and weight, and are vulnerable to social desirability and recall bias (Hassan 2006; Van de Mortel 2008). With self-report, it is possible that the participants had difficulty recalling and describing their behaviours or with understanding the written instructions and questions (Hassan 2006). A small pilot study for this current research, however, indicated that university-based young adults in Bangladesh did not have any difficulties with completing the survey, which was in English. Furthermore, the candidate explained the survey items to the participating students, and was present at the classrooms to answer questions and therefore minimise the risk of misunderstanding. It is, however, possible that participants were unwilling to provide information that they perceived as socio-culturally undesirable and/or tended to provide a favourable image of themselves (Van de Mortel 2008). Self-report is a common method to understand PA and SB, and the primary means by which to understand psychosocial factors e.g., outcome expectations, perceived environmental barriers to PA or subjective perceptions about neighbourhood safety (Burton et al. 2005; Ding et al. 2013). This information may have more practical value than objective measures about barriers or existence of facilities (Burton 2006; Giles-Corti & Donovan 2002).

The reliability and validity of the measures used to assess PA and SB have been established in Bangladesh, as a part of a global initiative (Bull et al. 2009); however, the psychometrics for GPAQ self-reported protocol has not been evaluated yet. The Kessler 6 Psychological Distress (K6) scale has good psychometric properties in other developed countries (Kessler et al. 2002; Kessler et al. 2010), but it has not yet been validated in Bangladeshi young adults. As a basic measure of wellbeing, K6 only assesses one aspect of psychological health (generic distress); thus, different results may have been obtained if other measures had been used e.g., specifically targeting depression, anxiety or positive wellbeing. The scale items that were used to assess PA efficacy, outcome expectations and social support, were based on relevant literature, but for some measures, selected items were used instead of the complete scale. Therefore, the original scales' psychometric properties are not applicable. Though these scales achieved acceptable levels of internal consistency in the current research, test-retest reliability or validity was not assessed; therefore, the temporal stability of these scales is unknown.

The research had two assessment points, one year apart. As a PhD project, it was impractical to follow the participants up for a longer period. Thus, the trajectory of PA and

SB cannot be described. It is also not possible to examine how these behaviours and their associations with psychological wellbeing evolve over the longer term.

Only individual-level correlates of PA, SB, and changes in PA and SB were assessed in this research program. Understanding and addressing individual-level correlates in isolation may not significantly change PA and SB (Bauman et al. 2012; O'Donoghue et al. 2016). The Socio-Ecological Model (SEM) suggests that in addition to interpersonal and intrapersonal correlates, PA can be associated with a number of environmental, regional and policy-level correlates (Bauman et al. 2012), which were not included in this current research. A supportive environment such as recreational facilities at convenient places, aesthetics, and an activity friendly transportation system, infrastructure and services (e.g., walking and bicycle trails, pedestrian friendly footpaths) can foster PA participation (Bauman et al. 2012; Bellew et al. 2011; Sallis 2009). Only a limited number of items were used to assess perceived environmental PA barriers, which may not have covered all possible factors. The correlates of SB, and changes in PA and SB, that were assessed focused on a limited number of items for sociodemographic, and health and lifestyle factors, however multi-level factors including intrapersonal, social, environmental and policy-level factors are likely to influence SB (O'Donoghue et al. 2016; Prince et al. 2017).

7.4 Strengths of the research

A major strength of this research project is the prospective design and focus on a lower-middle-income country. There is limited prospective research evidence on PA and SB in lower-middle-income countries (Bauman et al. 2012; Prince et al. 2017; Rhodes et al. 2017; Rhodes et al. 2012; Sallis et al. 2016). Between January 1999 and February 2015, 197 studies assessed correlates of PA in low- and middle-income countries (LMICs), of which 96% were of cross-sectional design and most were from upper-middle-income countries, with only 13% being from low-income and lower-middle-income countries (Sallis et al. 2016). Of the 26 correlate studies in low-income and lower-middle-income countries, only one study with adolescents used a prospective design (Sallis et al. 2016). Another strength of this current project is that a number of individual-level correlates of PA were studied, including psychological, social, health, lifestyle and sociodemographic factors. This offered a broad understanding of factors associated with PA of young adults in Bangladesh. Examining only sociodemographic correlates of PA may not be sufficient to inform effective interventions (Bauman et al. 2012).

The GPAQ, which was used to assess PA and SB in this current research program, was validated in Bangladeshi adults as a part of the WHO's global surveillance initiative of NCD risk factors (Bull et al. 2009). A major strength of the GPAQ includes its scope of assessing the key domains (work, transport and leisure) where PA occurs (Bull et al. 2009). PA is a complex behaviour, which can occur in different contexts with varying intensity and frequency of activity in each domain (Bull et al. 2009; Macniven et al. 2012). Many studies, however, report only on LTPA, which offers a 'small window' on total PA (Bauman et al. 2012). To ensure a comprehensive understanding of PA behaviour, it is essential to collect data on all PA domains (Bauman et al. 2012). This may be particularly important in LMICs where domestic and active transport activities may make a significant contribution to overall PA, especially for women.

A composite measure of PA and SB was used in this research project to assess possible associations with two measures of wellbeing. This extends the current evidence base that tends to focus on measures of SB and PA separately. To examine the independent effects of PA and SB, each was adjusted for the other. This reduced the potential confounding effect of PA and SB with each other in the models. To further minimise the confounding effects, a range of other potential covariates were also considered during the modelling including perceived health, dietary behaviour (e.g., frequency of fruit and fast food consumption), cigarette smoking, gender and BMI.

This research project recruited a moderately large and heterogeneous sample of university-based young adults with a balanced representation of gender and university types. The response rate at Wave 1 was high (92%) with a good retention rate at Wave 2 (69%). Another strength of the research program was piloting the questionnaire in a small sample of university students in Dhaka to evaluate feasibility and acceptability of administering the questionnaire in university students in Bangladesh.

7.5 Practical implications

The practical implications of this research project relate to developing interventions to promote PA and minimise SB among young adults in Bangladesh, and perhaps other LMICs that share similar socio-cultural norms. Results demonstrate that PA participation is low among young adults in urban Bangladesh; particularly among females. It is therefore recommended that PA intervention programs in this country have a strong focus on females.

The results that females are more concerned than males about safety, and that they are more likely to perceive their neighbourhood unsafe for PA, can partly explain their low PA participation, especially in transportation and recreational domains. To improve safety, a multidisciplinary approach needs to be adopted with involvement of local policing and the community, as well as long-term planning. One practical approach for this group could be developing university-based PA programs using the existing infrastructure, and to create new infrastructure for PA where needed. Onsite university programs may offer a sense of familiarity and security to female students compared to community-based programs. There is strong evidence from other research that school-based interventions are successful in promoting PA among adolescents in LMICs (Filho et al. 2016). It is therefore possible that such an approach (i.e., institution-based PA programs) could be effective for young university-based adults in LMICs like Bangladesh.

It is recommended that universities create PA opportunities for their students with female friendly PA facilities. A female only gym or fitness centre, or a gym with dedicated hours for females, could be a practical option. Such facilities should include designated areas for females such as change rooms (i.e., shower, toilet cubicles) and ensure sufficient lighting in and around the facilities to promote safety. These facilities ideally should be indoors as females may be uncomfortable with outdoor PA facilities given the gender norms in Bangladeshi culture, and such facilities may not be socio-culturally acceptable. The current research suggests that females may be more interested in indoor PA such as yoga and use of a stationary exercise bike. Provisions for such indoor PA infrastructure are more practical and reasonable than outdoor facilities, as many universities in Dhaka city (especially private universities) do not have enough open outdoor space. To offer additional PA opportunities, home-based PA equipment could be offered and PA facilities for females could be created in local residential areas, such as dedicated rooms in apartment buildings.

Participants were more sedentary during weekend days than weekdays. Given the implications of prolonged SB for health, it is therefore important that initiatives be taken to reduce weekend day SB. By improving young adults' weekend PA (e.g. arranging football or cricket matches during weekend days) SB may be displaced and discouraged. The results indicated that social sedentary time (e.g., sitting-talking) and prolonged time on phone conversation were more common among females, which perhaps displaced time for PA. Social opportunities for PA, such as groups or team sports may therefore be attractive to females. Universities can also set up screening for insufficient PA and prolonged SB

(e.g., online self-assessment), and provide rapid feedback to the students about their activity behaviours. Such an endeavour can opportunistically identify the students in need of additional support for activity behaviours with a relatively smaller budget within the university setting.

For positive wellbeing, promoting PA perhaps is more strategically important than reducing SB in this population group. Universities could consider developing a wellbeing program that includes activities such as information on PA awareness and benefits for wellbeing. Such programs can provide peer support for PA, and strategies to adopt and maintain PA for wellbeing. Young adults who report sleep difficulties or stress could be targeted to participate in PA or organised sports.

7.6 Policy implications

To address the high prevalence of insufficient PA and prolonged SB among young adults in Bangladesh, a national policy for active lifestyles that identify both PA and SB is needed and highly recommended. PA and SB have not been recognised as a priority in the existing Bangladesh National Health Policy (Ministry of Health and Family Welfare 2011). Bangladesh has a National Sports Policy, which emphasises PA opportunities for children and adolescents (e.g., educational institution-based sports facilities) but not for young adults. This policy, dated in 1998, has been poorly implemented and operationalised (Biswas et al. 2017). The existing National Youth Policy (2003) recognises the importance of sports and healthy recreation for youth; however, there is no visible resource allocation in this sector, and seemingly, little attention has been paid to operationalise this policy (Department of Youth Development 2003). NCDs account for over half of the annual mortality in Bangladesh (Bleich et al. 2011) and insufficient PA is the third leading risk factor of NCDs in Bangladesh (Zaman et al. 2015). Given the steady increase in NCDs among young adults in recent years in the country (Global Burden of Disease n.d.), the findings of this research project call for government support by recognising these behaviours as a health priority for young adults, and taking initiatives to improve their activity behaviours. The government should attract organisations that work on promoting PA or sports through grants or subsidies, offering financial aid and/or preferential loan. Strategic and systematic government investments in PA infrastructures could have a positive impact on the health and wellbeing of young adults.

While recreational PA is important, it is also essential to address how government can support transport-related PA such as walking and bicycling. Sustainable transport systems encouraging active transport can help reduce SB and foster PA (Ainsworth & Macera 2018; Henry & Scott 2017; Pucher & Dijkstra 2003). More than half of the participants in this current research project perceived the poor condition of footpaths as barriers to PA. Dumping of construction materials, illegal motor vehicle parking, temporary shops and street vendors make many footpaths in Dhaka inaccessible to the pedestrians (Efroymson & Hossain 2015). Recently, the Dhaka Bus Rapid Transit Walkability Strategy (Asian Developmnet Bank 2012) recommended construction material dumping prohibition policy and hawker support and management policy to mitigate these challenges. Development, introduction and operationalisation of such policies may create a pedestrian friendly, safe and comfortable footpath in Dhaka.

In cities like Dhaka, heavy traffic can be a major barrier to active travel. People often perceive heavy traffic as a safety hazard (SWOV 2012). Findings of this research program confirmed heavy traffic as a perceived environmental barrier to young adults' PA. Though the National Integrated Multimodal Transport Policy 2013 encouraged active commuting and advocated for walking and bicycling as a primary mode of transport (Ministry of Communication 2013), the existing infrastructure is unlikely to be sufficient for active travel. To encourage people to walk or bicycle, it is imperative to reconsider the existing road use system and traffic congestion issues in Dhaka city. It would be impractical to recommend separate bicycle lanes given that most of the roads are narrow with buildings close to roads and no space for additional lanes. Some pragmatic strategies, such as toll roads, road space rationing (e.g., vehicle use rotation), fees to enter a heavy traffic zone and car-free weekends, can help to mitigate traffic congestion, improve walkability and encourage active transport. Government can consider these approaches and support the existing Bangladesh National Integrated Multimodal Transport Policy for active commuting.

To ensure active, sustainable and 'eco-friendly' modes of commuting, government policies should support bicycle activism, and introduce educational projects and/or campaigns to promote the use of active transport. The mass media, print media and social marketing can be used to promote positive values for active transport. The government should endorse bicycle initiatives such as bike sharing or bike rental programs and introduce public bicycles, which have been successful in highly populated cities in LMICs such as India, China and Mexico (Dhingra & Kodukula 2010; Shaheen et al. 2010). The

government should also consider encouraging local bicycle industries by reducing sales taxes, import taxes for bicycles and offer special discounts to attract young consumers.

Given the increasing burden of NCDs, it is important to set priorities for a health surveillance system for key NCD risk factors, such as PA and SB. The Bangladesh Demographic and Health Survey (BDHS), a nationally representative sample survey, periodically collects data on different aspects of health (e.g., sexual health, sexually transmitted diseases, nutrition) in the Bangladeshi population (National Institute of Population Research and Training - Bangladesh). As of 2018, seven rounds of BDHS surveys have been implemented over the past two decades (National Institute of Population Research and Training - Bangladesh). Although smoking, nutrition and sexual health are included in the BDHS, PA and SB, however, are not included in this national initiative. It is recommended that surveillance of PA and SB either be integrated within the BDHS protocol or government-aided such surveillance programs be developed. The WHO's School-based Student Health Survey (GSHS) collects data on PA and screen-time of school-aged children (13-17 years) in Bangladesh (World Health Organization 2014). Within the WHO's NCD surveillance program STEPS in Bangladesh, PA and SB data are collected for adults aged ≥25 years (World Health Organization 2011), but not for those aged <25 years. It is therefore recommended that young adults aged 18-24 years are included in the STEPS surveillance program as other South Asian countries do e.g., India, Bhutan, Nepal, Sri Lanka and Maldives (details can be found in the WHO website: http://www.who.int/ncds/surveillance/steps/reports/en/).

A designated government-endorsed and/or funded institute to promote active lifestyles in Bangladesh is a timely call for action. Such an institution could take a leadership role in promoting healthy activity behaviours in Bangladesh and enable multi-sectoral coordination between government, the non-government sector including aid-agencies and non-government organisations (NGOs), public health researchers, other healthcare professionals and the mass media including print and digital media. The non-government sector, especially the NGOs and aid agencies have extensively contributed to the health sector in Bangladesh (El Arifeen et al. 2013; Sarwar 2015). A strategic partnership between government and non-government sector could be successful in promoting active lifestyles in the country. NGOs and the mass media can be used to mobilise efforts to encourage PA and discourage sedentary lifestyle by organising educational programs and awareness campaigns. The government investment in research

by prioritising funding for active lifestyle projects, and targeting young adults, could contribute to improve health and wellbeing of people in Bangladesh.

7.7 Recommendations for future research

Recommendations for future research in this area primarily relate to the representativeness of research participants, long-term prospective data, and measurement. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), gross tertiary education enrolment ratio is just over 17% in Bangladesh (United Nations Educational n.d.), which indicates a large proportion of young adults do not attend university. It is therefore recommended that future research focuses on population-based studies with a more representative sample of young adults from rural, regional and metropolitan areas.

To understand the trajectory of PA and SB, and to assess associated factors, long-term prospective studies with more assessment points are recommended. This is required to identify determinants that have strong causal relationships, and the direction of associations with PA and SB. Such studies can also help examine how the association of PA and SB with different aspects of physical and psychological health evolve over the long-term. This may be particularly important in young adulthood that is subject to many significant life challenges such as securing employment, moving out of the family home, marriage, or having children.

Within a surveillance framework to understand the prevalence of PA and SB in a large population-based representative sample, the use of objective measures to assess these behaviours may be impractical. When possible however, it is recommended that future research also uses objective measures of PA and SB (e.g., accelerometry). This may be particularly important for SB, given that many self-report measures of SB have demonstrated poor validity (Chastin et al. 2018). Objective data can provide a complement to subjective data needed to understand contextual information.

It is recommended that future research on the correlates of PA and SB be driven by the principles of the social ecological model (SEM) (Bauman et al. 2012). A comprehensive SEM-based framework including individual, social, environmental, and policy-level factors is a prerequisite to understand all level of influences of these

behaviours. This can ensure '*all-inclusive*' evidence for multilevel interventions, which may offer the best chance for success (Bauman et al. 2012; Prince et al. 2017).

The current research project did not find any significant independent adverse effect of SB on wellbeing. It has been suggested elsewhere that not all types of sedentary activities are associated with poor psychological wellbeing and the adverse effects can be specific to the context of SB (Ferguson 2015). It is therefore recommended that future research examines how different types of SB are associated with psychological wellbeing of young adults. It is also recommended that future research uses population-specific valid measures of psychological wellbeing, and consider multi-component aspects of wellbeing including anxiety, stress, depression, sleep, quality of life, positive wellbeing and self-esteem.

7.8 Conclusions

This research program demonstrated a high prevalence of insufficient PA and prolonged SB among university-based young adults in Dhaka city, Bangladesh, in particular among young adult females. Findings suggest a gender-based difference in the patterns of PA participation, with female young adults engaging in indoor activities and males in outdoor activities. Females spent more SB time in siting-talking, using phone and/or watching TV than their male counterparts did. Perceived environmental barriers to PA, especially safety concerns, were more salient to females than males. PA outcome expectations (e.g., weight management, improved health) and older age were positively associated with PA of young adult females. Insufficient PA was associated with psychological distress regardless of SB. Insufficient PA independently, and in combination with high SB, was associated with sleep difficulties. However, there was no significant independent adverse effect of SB on psychological distress.

These findings provide a justification for intervention programs to improve PA and minimise SB among young adults, in particular among females, in urban Bangladesh. Recommendations include creating female-friendly onsite university-based PA facilities, female only gym or dedicated hours for females, providing home-based PA equipment and indoor female friendly PA facilities at local residential areas. To reduce or displace weekend day SB, it is recommended that opportunities be created for young adults to engage in weekend PA. Group and team sports are recommended as social activities to offset the time female young adults' spend in social sedentary activities.

A PA policy for Bangladesh is timely and highly recommended. Other government areas of investment should include creating or improving infrastructures for healthy activity behaviours, implementing existing policies for active commuting and recreational PA with adequate resource allocation to promote sports and active travel, and investing in national surveillance of PA and SB.

More prospective research is needed to ensure a comprehensive understanding of the prevalence, patterns, and determinants of PA and SB, the trajectory of these behaviours, their associations with health outcomes including psychological wellbeing. Objective measures of PA and SB, context specific measures of SB and measures of different aspects of psychological health are recommended. Future long-term prospective research should be with representative and population-based samples including young adults from rural, regional and metropolitan areas.

A comprehensive understanding of these behaviours among young adults in Bangladesh can inform evidence-based interventions to promote an active healthy lifestyle characterised by sufficient PA and reduced time in SB. This can reduce the burden of morbidity, mortality and health expenditure associated with an inactive lifestyle; and improve overall health and wellbeing of young adults in Bangladesh. Such evidence may also be helpful for initiatives in other LMICs, and contribute to improvements in overall health and wellbeing of young adults globally.

References

Abdullah A, Mirzaei NF, Haron SH. 2016. Perception of neighbourhood-level built environment in relation to youth physical activity in Malaysia. *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*, **10**: 3446-51.

Abegunde DO, Mathers CD, Adam T, Ortegon M, Strong K. 2007. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet*, **370**: 1929-38.

Adams TB, Colner W. 2008. The association of multiple risk factors with fruit and vegetable intake among a nationwide sample of college students. *Journal of American College Health*, **56**: 455-61.

Ainsworth BE, Haskell WL, Herrmann SD, et al. 2011. 2011 compendium of physical activities: a second update of codes and MET values. *Medicine and Science in Sports and Exercise*, **43**: 1575-81.

Ainsworth BE, Macera CA. 2018. Promoting physical activity in a public health context. *Journal of Sport and Health Science*, **7**: 1-2.

Airin J, Begum A, Ali M, Ahamd M. 2015. Eve teasing and adolescent's depression. *Journal of Armed Forces Medical College, Bangladesh*, **10**: 3-8.

Al-Eisa E, Buragadda S, Melam GR. 2014. Association between physical activity and psychological status among Saudi female students. *BMC Psychiatry*, **14**: 238.

Allan JD. 1987. Identification of health risks in a young adult population. *Journal of Community Health Nursing*, **4**: 223-33.

Anjana RM, Pradeepa R, Das AK, et al. 2014. Physical activity and inactivity patterns in India - results from the ICMR-INDIAB study (Phase-1) [ICMR-INDIAB-5]. *The International Journal of Behavioral Nutrition and Physical Activity*, **11**: 26.

Arias-Palencia NM, Solera-Martínez M, Gracia-Marco L, et al. 2015. Levels and patterns of objectively assessed physical activity and compliance with different public health guidelines in university students. *PloS One*, **10**: e0141977.

Ariffin RNR, Zahari RK. 2013. Perceptions of the urban walking environments. *Procedia-Social and Behavioral Sciences*, **105**: 589-97.

Armstrong T, Bull F. 2006. Development of the World Health Organization Global Physical Activity Questionnaire (GPAQ). *Journal of Public Health*, **14**: 66-70.

Arnett JJ. 2000. Emerging adulthood: a theory of development from the late teens through the twenties. *American Psychologist*, **55**: 469-80.

Asian Developmnet Bank. 2012. Moving dangerously, moving pleasurably: Improving walkability in Dhaka. Asian Development Bank technical assistance consultant's report (2012).

Assah F, Mbanya JC, Ekelund U, Wareham N, Brage S. 2015. Patterns and correlates of objectively measured free-living physical activity in adults in rural and urban Cameroon. *Journal of Epidemiology and Community Health*, **69**: 700-07.

Atkinson G, Davenne D. 2007. Relationships between sleep, physical activity and human health. *Physiology & Behavior*, **90**: 229-35.

Awadalla NJ, Aboelyazed AE, Hassanein MA, et al. 2014. Assessment of physical inactivity and perceived barriers to physical activity among health college students, south-western Saudi Arabia. *Eastern Mediterranean Health Journal*, **20**: 596-604.

Babbie E. 2015. *The practice of social research*. Cengage Learning, CA: USA.

Bagherniya M, Sharma M, Mostafavi F, Keshavarz SA. 2015. Application of social cognitive theory in predicting childhood obesity prevention behaviors in overweight and obese Iranian adolescents. *International Quarterly of Community Health Education*, **35**: 133-47.

Bandura A. 1986. Social foundations of thought and action: A social cognitive perspective. *Englewood Cliffs, NJ: USA*.

Bangladesh Demographic and Health Survey. 2013. The 2011 Bangladesh Demographic and Health Survey 2011. Dhaka, Bangladesh and Calverton, Maryland, USA: ICF International, MD: USA.

Baranowski T, Perry CL, Parcel GS. 2002. How individuals, environments, and health behavior interact. In: Glanz K, Rimer BK, Lewis FM (eds). *Health behavior and health education.* 3rd edn. San Francisco, CA: Jossey-Bass, 165-84.

Bartel KA, Gradisar M, Williamson P. 2015. Protective and risk factors for adolescent sleep: a meta-analytic review. *Sleep Medicine Reviews*, **21**: 72-85.
Bauman AE, Petersen CB, Blond K, Rangul V, Hardy LL. 2018. The Descriptive Epidemiology of Sedentary Behaviour. In: Leitzmann MF, Jochem C, Schmid D (eds). *Sedentary Behaviour Epidemiology.* Springer, 73-106.
Bauman AE, Reis RS, Sallis JF, et al. 2012. Correlates of physical activity: why are some people physically active and others not? *Lancet*, **380**: 258-71.
Bayram N, Bilgel N. 2008. The prevalence and socio-demographic correlations of depression, anxiety and stress among a group of university students. *Social Psychiatry and Psychiatric Epidemiology*, **43**: 667-72.
Bellew B, Bauman A, Martin B, Bull F, Matsudo V. 2011. Public policy actions needed to promote physical activity. *Current Cardiovascular Risk Reports*, **5**: 340-49.
Bennie JA, Pedisic Z, van Uffelen JG, et al. 2016. The descriptive epidemiology of total physical activity, muscle-strengthening exercises and sedentary behaviour among Australian adults–results from the National Nutrition and Physical Activity Survey. *BMC Public Health*, **16**: 73.
Berg CJ, Goodwin SB, Stratton E, et al. 2014. Physical activity and fruit and vegetable intake among black and white female college students at two- and four-year colleges and universities. *Open Journal of Preventive Medicine*, **4**: 229-39.
Berngruber A. 2016. Leaving the parental home as a transition marker to adulthood. *Routledge Handbook of Youth and Young Adulthood*. Routledge, NY: USA. pp.193.
Berryman JW. 2010. Exercise is medicine: a historical perspective. *Current sports Medicine Reports*, **9**: 195-201.
Biddle S, Cavill N, Ekelund U, et al. 2010a. Sedentary behaviour and obesity: review of the current scientific evidence. Department For Children, Schools and Families, London, United Kingdom. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213745/dh_128225.pdf [Accessed: 9 May 2018].
Biddle SJ, Brehm W, Verheijden M, Hopman-Rock M. 2012. Population physical activity behaviour change: A review for the European College of Sport Science. *European Journal of Sport Science*, **12**: 367-83.
Biddle SJ, Nigg CR. 2000. Theories of exercise behavior. *International Journal of Sport Psychology*, **31**: 290-304.
Biddle SJH, Pearson N, Ross GM, Braithwaite R. 2010b. Tracking of sedentary behaviours of young people: A systematic review. *Preventive Medicine*, **51**: 345-51.
Biswas A, Oh PI, Faulkner GE, et al. 2015. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Annals of Internal Medicine*, **162**: 123-32.
Biswas T, Pervin S, Tanim MIA, Niessen L, Islam A. 2017. Bangladesh policy on prevention and control of non-communicable diseases: a policy analysis. *BMC Public Health*, **17**: 582.
Blair J, Czaja RF. 2014. *Designing surveys: A guide to decisions and procedures*. 3rd edn. Sage Publications, Thousand Oaks, CA: USA.
Blair SN, Kohl HW, Gordon NF, Paffenbarger Jr RS. 1992. How much physical activity is good for health? *Annual Review of Public Health*, **13**: 99-126.
Bleich SN, Koehlmoos TLP, Rashid M, Peters DH, Anderson G. 2011. Noncommunicable chronic disease in Bangladesh: overview of existing programs and priorities going forward. *Health Policy*, **100**: 282-89.
Booth M. 2000. Assessment of physical activity: an international perspective. *Research Quarterly for Exercise and Sport*, **71**: 114-20.
Bowling A. 2005. Mode of questionnaire administration can have serious effects on data quality. *Journal of Public Health*, **27**: 281-91.
Briffa TG, Maiorana A, Sheerin NJ, et al. 2006. Physical activity for people with cardiovascular disease: recommendations of the National Heart Foundation of Australia. *Medical Journal of Australia*, **184**: 71-75.
Brown GM. 2010. *Knowledge, engagement, and perceptions of the american college of sports medicine guidelines for cardiovascular physical activity: a university undergraduate comparison*. Doctoral dissertation, University of Alabama Libraries.

Bruffaerts R, Mortier P, Kiekens G, et al. Mental health problems in college freshmen: prevalence and academic functioning. *Journal of Affective Disorders*, **225**: 97-103.
Brug J, Oenema A, Ferreira I. 2005. Theory, evidence and Intervention Mapping to improve behavior nutrition and physical activity interventions. *International Journal of Behavioral Nutrition and Physical Activity*, **2**: 2.
Brymer E, Davids K. 2016. Designing environments to enhance physical and psychological benefits of physical activity: a multidisciplinary perspective. *Sports Medicine*, **46**: 925–26.
Buchan DS, Ollis S, Thomas NE, Baker JS. 2012. physical activity behaviour: an overview of current and emergent theoretical practices. *Journal of Obesity*, **2012**: 546459.
Buckworth J, Nigg C. 2004. Physical activity, exercise, and sedentary behavior in college students. *Journal of American College Health*, **53**: 28-34.
Bull FC, Maslin TS, Armstrong T. 2009. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *Journal of Physical Activity and Health*, **6**: 790-804.
Burg MM, Schwartz JE, Kronish IM, et al. 2017. Does stress result in you exercising less? Or does exercising result in you being less stressed? Or is it both? Testing the bi-directional stress-exercise association at the group and person (N of 1) level. *Annals of Behavioral Medicine*, **51**: 799-809.
Burton NW. 2006. The relative contribution of psychological, social, and environmental variables to explain variation in leisure-time physical activity among adults at a population level. Doctoral dissertation, Queensland University of Technology.
Burton NW, Turrell G, Oldenburg B, Sallis JF. 2005. The relative contributions of psychological, social, and environmental variables to explain participation in walking, moderate-, and vigorous-intensity leisure-time physical activity. *Journal of Physical Activity and Health*, **2**: 181-96.
Caglar E, Bilgili N, Karaca A, Deliceoglu G. 2017. Screen time differences among Turkish university students as an indicator of sedentary lifestyle and inactivity. *Croatian Journal of Education*, **19**: 1105-30.
Cao H, Qian Q, Weng T, et al. 2011. Screen time, physical activity and mental health among urban adolescents in China. *Preventive Medicine*, **53**: 316-20.
Cashmore J, Parkinson P. 2014. The use and abuse of social science research evidence in children's cases. *Psychology, Public Policy, and Law*, **20**: 239-250.
Caspersen CJ, Powell KE, Christenson GM. 1985. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports*, **100**: 126-31.
Chandiramani J, Airy A. 2018. Urbanization and socio-economic growth in south asia region. In: Benna U, Benna I (eds). *Urbanization and Its Impact on Socio-Economic Growth in Developing Regions.* IGI Global, PA:USA. pp.130-54.
Chang P-C, Li T-C, Wu M-T, et al. 2008. Association between television viewing and the risk of metabolic syndrome in a community-based population. *BMC Public Health*, **8**: 193.
Chastin S, Dontje ML, Skelton DA, et al. 2018. Systematic comparative validation of self-report measures of sedentary time against an objective measure of postural sitting (activPAL). *International Journal of Behavioral Nutrition and Physical Activity*, **15**: 21.
Chastin SF, Buck C, Freiberger E, et al. 2015. Systematic literature review of determinants of sedentary behaviour in older adults: a DEDIPAC study. *International Journal of Behavioral Nutrition and Physical Activity*, **12**: 127.
Chau JY, Grunseit A, Midthjell K, et al. 2015. Sedentary behaviour and risk of mortality from all-causes and cardiometabolic diseases in adults: evidence from the HUNT3 population cohort. *British Journal of Sports Medicine*, **49**: 737-42.
Chau K. 2015. Impact of sleep difficulty on single and repeated injuries in adolescents. *Accident Analysis & Prevention*, **81**: 86-95.
Chennaoui M, Arnal PJ, Sauvet F, Léger D. 2015. Sleep and exercise: a reciprocal issue? *Sleep Medicine Reviews*, **20**: 59-72.
Choudhury T. 2017. Women and migration: transition, agency and labour. *Journal of Alternative Perspectives in the Social Sciences*, **8**: 299-322.
Chowdhury AMR, Bhuiya A, Chowdhury ME, et al. 2013. The Bangladesh paradox: exceptional health achievement despite economic poverty. *Lancet*, **382**: 1734-45.

Chowdhury MAB, Uddin MJ, Haque MR, Ibrahimou B. 2016. Hypertension among adults in Bangladesh: evidence from a national cross-sectional survey. *BMC Cardiovascular Disorders*, **16**: 22.
Christakis NA, Fowler JH. 2007. The spread of obesity in a large social network over 32 years. *New England Journal of Medicine*, **357**: 370-79.
Chu AH, Ng SH, Koh D, Muller-Riemenschneider F. 2015. Reliability and validity of the self- and interviewer-administered versions of the Global Physical Activity Questionnaire (GPAQ). *PloS One*, **10**: e0136944.
Chung K-F, Cheung M-M. 2008. Sleep-wake patterns and sleep disturbance among Hong Kong Chinese adolescents. *Sleep*, **31**: 185-94.
Churangsarit S, Chongsuvivatwong V. 2011. Spatial and social factors associated with transportation and recreational physical activity among adults in Hat Yai City, Songkhla, Thailand. *Journal of Physical Activity and Health*, **8**: 758-65.
CIA. 2016. The World Factbook, South Asia: Bangladesh. USA: The Central Intelligence Agency.
Clarke PJ, O'malley PM, Johnston LD, Schulenberg JE, Lantz P. 2009. Differential trends in weight-related health behaviors among American young adults by gender, race/ethnicity, and socioeconomic status: 1984–2006. *American Journal of Public Health*, **99**: 1893-901.
Colten HR, Altevogt BM. 2006. Committee on Sleep Medicine and Research, Board on Health Sciences Policy. Extent and health consequences of chronic sleep loss and sleep disorders. *Sleep disorders and sleep deprivation: an unmet public health problem.* National Academies Press, DC: USA. pp.55-135.
Corder K, Winpenny E, Love R, et al. 2017. Change in physical activity from adolescence to early adulthood: a systematic review and meta-analysis of longitudinal cohort studies. *British Journal of Sports Medicine*: doi: 10.1136/bjsports-2016-09733.
Cox EP, O'Dwyer N, Cook R, et al. 2016. Relationship between physical activity and cognitive function in apparently healthy young to middle-aged adults: a systematic review. *Journal of Science and Medicine in Sport*, **19**: 616-28.
Cox W. 2016. Demographia World Urban Areas 12th Annual Edition: 2016:04.
Craig C, Marshall A, Sjostrom M. 2003. International physical activity questionnaire: 12-country reliability and validity. *Medicine & Science in Sports & Exercise*, **35**: 1381-95.
de Courten M. 2002. Developing a simple global physical activity questionnaire for population studies. *Australasian Epidemiologist*, **9**: 6-9.
Deliens T, Clarys P, Van Hecke L, De Bourdeaudhuij I, Deforche B. 2013. Changes in weight and body composition during the first semester at university. A prospective explanatory study. *Appetite*, **65**: 111-16.
Deliens T, Deforche B, De Bourdeaudhuij I, Clarys P. 2015. Determinants of physical activity and sedentary behaviour in university students: a qualitative study using focus group discussions. *BMC Public Health*, **15**: 201.
Department of Youth Development. 2003. Bangladesh National Youth Policy. Department of Youth Development. People's Republic of Bangladesh.
Desai PB. 2002. Cancer control efforts in the Indian subcontinent. *Japanese Journal of Clinical Oncology*, **32**: S13-S16.
Dhingra C, Kodukula S. 2010. Public bicycle schemes: Applying the concept in developing cities. GTZ Sustainbale Urban Project. New Delhi: India. pp.32.
Ding D, Adams MA, Sallis JF, et al. 2013. Perceived neighborhood environment and physical activity in 11 countries: do associations differ by country? *International Journal of Behavioral Nutrition and Physical Activity*, **10**: 57.
Ding D, Lawson KD, Kolbe-Alexander TL, et al. 2016. The economic burden of physical inactivity: a global analysis of major non-communicable diseases. *Lancet*, **388**: 1311-24.
Ding D, Sallis JF, Hovell MF, et al. 2011. Physical activity and sedentary behaviours among rural adults in Suixi, China: a cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity*, **8**: 37.
Dolton P. 2003. Reducing attrition bias using targeted refreshment sampling and matching. 65 edn: Royal Economic Society.
Drake C, Roehrs T, Shambroom J, Roth T. 2013. Caffeine effects on sleep taken 0, 3, or 6 hours before going to bed. *Journal of Clinical Sleep Medicine*, **9**: 1195-200.

Dumith SC, Gigante DP, Domingues MR, et al. 2012. Predictors of physical activity change during adolescence: a 3· 5-year follow-up. *Public Health Nutrition*, **15**: 2237-45.
Dumith SC, Hallal PC, Reis RS, Kohl HW, 3rd. 2011. Worldwide prevalence of physical inactivity and its association with human development index in 76 countries. *Preventive Medicine*, **53**: 24-28.
Dunstan DW, Barr EL, Healy GN, et al. 2010. Television viewing time and mortality: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Circulation*, **121**: 384-91.
Edwards MK, Loprinzi PD. 2016. Effects of a sedentary behavior–inducing randomized controlled intervention on depression and mood profile in active young adults. *Mayo Clinic Proceedings*, **91**: 984-98.
Efroymson D, Hossain M. 2015. Improving conditions for walking: research and action in Dhaka, Bangladesh. *Journeys*: 49-58.
El Arifeen S, Christou A, Reichenbach L, et al. 2013. Community-based approaches and partnerships: innovations in health-service delivery in Bangladesh. *Lancet*, **382**: 2012-26.
Espie CA, Inglis SJ, Tessier S, Harvey L. 2001. The clinical effectiveness of cognitive behaviour therapy for chronic insomnia: implementation and evaluation of a sleep clinic in general medical practice. *Behaviour Research and Therapy*, **39**: 45-60.
Farrington DP. 1991. Longitudinal research strategies: advantages, problems, and prospects. *Journal of the American Academy of Child and Adolescent Psychiatry*, **30**: 369-74.
Faruq MO, Rahman MM, Alam MR. 2017. Impact of social networking sites in Bangladesh: few possible solutions. *International Journal of Intelligent Systems and Applications*, **9**: 53-60.
Feng Q, Zhang Q-l, Du Y, Ye Y-l, He Q-q. 2014. Associations of physical activity, screen time with depression, anxiety and sleep quality among Chinese college freshmen. *PloS One*, **9**: e100914.
Ferguson CJ. 2015. Do angry birds make for angry children? A meta-analysis of video game influences on children's and adolescents' aggression, mental health, prosocial behavior, and academic performance. *Perspectives on Psychological Science*, **10**: 646-66.
Filho BVC, Minatto G, Mota J, et al. 2016. Promoting physical activity for children and adolescents in low- and middle-income countries: an umbrella systematic review: a review on promoting physical activity in LMIC. *Preventive Medicine*, **88**: 115-26.
Fincham SM, Roomaney R, Kagee A. 2015. The relationship between worldview, self-efficacy, psychological distress, and a health-promoting lifestyle among a South African undergraduate university sample. *South African Journal of Psychology*, **45**: 508-20.
Foster S, Giles-Corti B. 2008. The built environment, neighborhood crime and constrained physical activity: an exploration of inconsistent findings. *Preventive Medicine*, **47**: 241–51.
Foti KE, Eaton DK, Lowry R, McKnight-Ely LR. 2011. Sufficient sleep, physical activity, and sedentary behaviors. *American Journal of Preventive Medicine*, **41**: 596-602.
Frerichs L, Huang TT-K, Chen D-R. 2014. Associations of subjective social status with physical activity and body mass index across four Asian countries. *Journal of Obesity*, **2014:** 710602.
Furukawa TA, Kessler RC, Slade T, Andrews G. 2003. The performance of the K6 and K10 screening scales for psychological distress in the Australian National Survey of Mental Health and Well-Being. *Psychological Medicine*, **33**: 357-62.
Gary AB. 2004. Using Generalized Estimating Equations for longitudinal data analysis. *Organizational Research Methods*, **7**: 127-50.
Ghorbani F, Heidarimoghadam R, Karami M, et al. 2014. The effect of six-week aerobic training program on cardiovascular fitness, body composition and mental health among female students. *Journal of Research in Health Sciences*, **14**: 264-67.
Gibb SJ, Fergusson DM, Horwood LJ. 2010. Burden of psychiatric disorder in young adulthood and life outcomes at age 30. *British Journal of Psychiatry*, **197**: 122-27.
Giles-Corti B, Donovan RJ. 2002. Socioeconomic status differences in recreational physical activity levels and real and perceived access to a supportive physical environment. *Preventive Medicine*, **35**: 601-11.
Glanz K, Maddock J. 2002. Behavior, Health-Related. *Encyclopedia of Public Health.* Available at: https://www.encyclopedia.com/medicine/psychology/psychology-and-psychiatry/health-behavior. [Accessed: 31 May 2015].

Glanz K, Rimer BK, Viswanath K. 2008. *Health behavior and health education: theory, research, and practice*. John Wiley & Sons, CA: USA.
Global Burden of Disease. n.d. Global Burden of Disease. Available at: http://www.healthdata.org/gbd-data-tool [Accessed: 18 Jun. 2016]
Goetz AM. 2013. Dis/organizing gender: women development agents in state and NGO poverty-reduction programmes in Bangladesh. In: Rai SM, Lievesley G (eds). *Women and the state: international perspectives.* Routledge, NY: USA. pp.126.
Goldbacher EM, Matthews KA. 2007. Are psychological characteristics related to risk of the metabolic syndrome? A review of the literature. *Annals of Behavioral Medicine*, **34**: 240-52.
Goodburn EA, Ross DA. 2000. Young people's health in developing countries: a neglected problem and opportunity. *Health Policy and Planning*, **15**: 137-44.
Gordon-Larsen P, Hou N, Sidney S, et al. 2009. Fifteen-year longitudinal trends in walking patterns and their impact on weight change. *American Journal of Clinical Nutrition*, **89**: 19-26.
Gordon-Larsen P, Nelson MC, Popkin BM. 2004. Longitudinal physical activity and sedentary behavior trends: adolescence to adulthood. *American Journal of Preventive Medicine*, **27**: 277–83.
Gore FM, Bloem PJN, Patton GC, et al. 2011. Global burden of disease in young people aged 10–24 years: a systematic analysis. *Lancet*, **377**: 2093-102.
Gostin LO, Abou-Taleb H, Roache SA, Alwan A. 2017. Legal priorities for prevention of non-communicable diseases: innovations from WHO's Eastern Mediterranean region. *Public Health*, **144**: 4-12.
Grøntved A, Hu FB. 2011. Television viewing and risk of type 2 diabetes, cardiovascular disease, and all-cause mortality: a meta-analysis. *Journal of the American Medical Association*, **305**: 2448-55.
Gulati A, Hochdorn A, Paramesh H, et al. 2014. Physical activity patterns among school children in India. *Indian Journal of Pediatrics*, **81**(S1): 47-54.
Gunnell KE, Flament MF, Buchholz A, et al. 2016. Examining the bidirectional relationship between physical activity, screen time, and symptoms of anxiety and depression over time during adolescence. *Preventive Medicine*, **88**: 147-52.
Guthold R, Ono T, Strong KL, Chatterji S, Morabia A. 2008. Worldwide variability in physical inactivity a 51-country survey. *American Journal of Preventive Medicine*, **34**: 486-94.
Haase A, Steptoe A, Sallis JF, Wardle J. 2004. Leisure-time physical activity in university students from 23 countries: associations with health beliefs, risk awareness, and national economic development. *Preventive Medicine*, **39**: 182-90.
Hagströmer M, Oja P, Sjöström M. 2006. The International Physical Activity Questionnaire (IPAQ): a study of concurrent and construct validity. *Public Health Nutrition*, **9**: 755-62.
Haile YG, Alemu SM, Habtewold TD. 2017. Insomnia and its temporal association with academic performance among university students: a cross-sectional study. *BioMed Research International*, **2017**: 2542367.
Hale L. 2005. Who has time to sleep? *Journal of Public Health (Oxf)*, **27**: 205-11.
Hallal PC, Andersen LB, Bull FC, et al. 2012. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet*, **380**: 247-57.
Hallal PC, Victora CG, Azevedo MR, Wells JC. 2006. Adolescent physical activity and health: a systematic review. *Sports Medicine*, **36**: 1019-30.
Hamer M. 2012. Psychosocial stress and cardiovascular disease risk: the role of physical activity. *Psychosomatic Medicine*, **74**: 896-903.
Hamer M, Smith L. 2018. Sedentary behaviour and depression. In: Leitzmann M, Jochem C, Schmid D (eds). *Sedentary Behaviour Epidemiology.* Springer International Publishing. pp.299-310.
Harari GM, Gosling SD, Wang R, et al. 2017. Patterns of behavior change in students over an academic term: a preliminary study of activity and sociability behaviors using smartphone sensing methods. *Computers in Human Behavior*, **67**: 129-38.
Hartescu I, Morgan K, Stevinson CD. 2015. Increased physical activity improves sleep and mood outcomes in inactive people with insomnia: a randomized controlled trial. *Journal of Sleep Research*, **24**: 526-34.
Hasnayen E, Sultana MS. 2016. Internet use in Bangladesh: problems and prospects. *International Journal of Computer Science and Information Technology Research*, **4**: 251-60.

Hassan E. 2006. Recall bias can be a threat to retrospective and prospective research designs. *Internet Journal of Epidemiology*, **3**: 339-412.
Henry M, Scott M. 2017. What gets measured gets what? The work of cycling indicators in a local government initiative. *New Zealand Geographer*, **73**: 109-18.
Henson J, Dunstan DW, Davies MJ, Yates T. 2016. Sedentary behaviour as a new behavioural target in the prevention and treatment of type 2 diabetes. *Diabetes/Metabolism Research and Reviews*, **32**: 213-20.
Herring MP, Monroe DC, Kline CE, O'Connor PJ, MacDonncha C. 2018. Sleep quality moderates the association between physical activity frequency and feelings of energy and fatigue in adolescents. *European Child & Adolescent Psychiatry*, **27**: 1425-32.
Hildum DC, Brown RW. 1956. Verbal reinforcement and interviewer bias. *Journal of Abnormal and Social Psychology*, **53**: 108-11.
Hino AA, Reis RS, Sarmiento OL, Parra DC, Brownson RC. 2011. The built environment and recreational physical activity among adults in Curitiba, Brazil. *Preventive Medicine*, **52**: 419-22.
Hoehner CM, Brennan Ramirez LK, Elliott MB, Handy SL, Brownson RC. 2005. Perceived and objective environmental measures and physical activity among urban adults. *American Journal of Preventive Medicine*, **28**: 105-16.
Hogan CL, Catalino LI, Mata J, Fredrickson BL. 2015. Beyond emotional benefits: physical activity and sedentary behaviour affect psychosocial resources through emotions. *Psychology & Health*, **30**: 354-69.
Hogan CL, Mata J, Carstensen LL. 2013. Exercise holds immediate benefits for affect and cognition in younger and older adults. *Psychology and Aging*, **28**: 587-94.
Hogan DP. 1978. The variable order of events in the life course. *American Sociological Review*, **43**: 573-86.
Hong M, Zhou Z-Y, Wan G. 2017. Food Security in Pakistan, Bangladesh, Indonesia, and Singapore. In: Zhou Z-Y, Wan G (eds). *Food Insecurity in Asia: Why Institutions Matter.* Asian Development Bank Institute, Tokyo: Japan. pp.257.
Hoyos Cillero I, Jago R. 2010. Systematic review of correlates of screen-viewing among young children. *Preventive Medicine*, **51**: 3-10.
Hoyt LT, Chase-Lansdale PL, McDade TW, Adam EK. 2012. Positive youth, healthy adults: Does positive well-being in adolescence predict better perceived health and fewer risky health behaviors in young adulthood? *Journal of Adolescent Health*, **50**: 66-73.
Hui S-kA, Grandner MA. 2015. Associations between poor sleep quality and stages of change of multiple health behaviors among participants of employee wellness program. *Preventive Medicine Reports*, **2**: 292-99.
icddrb. 2014. icddr,b media release: Adult rates of overweight and obesity rise in Bangladesh. Available at: http://www.icddrb.org/media-centre/media-releases/doc_download/8037-adult-rates-of-overweight-and-obesity-rise-in-bangladesh. [Accessed: 2 Jun. 2015].
International Diabetes Federation (IDF). 2015. IDF Diabetes Atlas. 7edn. IDF, Brussels: Belgium.
International Diabetes Federation (IDF). 2013. IDF Diabetes Atlas. 6edn. IDF, Brussels: Belgium.
Irwin MR. 2015. Why sleep is important for health: a psychoneuroimmunology perspective. *Annual Review of Psychology*, **66**: 143-72.
Islam A, Biswas T. 2015. Mental health and the health system in Bangladesh: situation analysis of a neglected domain. *American Journal of Psychiatry and Neuroscience*, **3**: 57-62.
Islam I, Mostaquim ME, Biswas SK. 2016. Analysis of possible causes of road congestion problem in Dhaka city. *Imperial Journal of Interdisciplinary Research*, **2**: 42-47.
Islam MM. 2016. Demographic transition and the emerging windows of opportunities and challenges in Bangladesh. *Journal of Population Research*, **33**: 283-305.
Islam N. Problems of women's education and role of Open University (Bangladesh perspective). *Paper presented at Pan-Commonwealth Forum 7 (PCF7)*, Abuja, Nigeria. Available at: http://oasis.col.org/handle/11599/2037. [Accessed: 2 May 2015].
Islam SMS, Lechner A, Ferrari U, et al. 2017. Healthcare use and expenditure for diabetes in Bangladesh. *BMJ Global Health*, **2**: e000033.
Itani O, Jike M, Watanabe N, Kaneita Y. 2017. Short sleep duration and health outcomes: a systematic review, meta-analysis, and meta-regression. *Sleep Medicine*, **32**: 246-56.

Jakicic JM, King WC, Marcus MD, et al. 2015. Short-term weight loss with diet and physical activity in young adults: The IDEA study. *Obesity*, **23**: 2385-97.
Janssen I, Dugan SA, Karavolos K, Lynch EB, Powell LH. 2014. Correlates of 15-year maintenance of physical activity in middle-aged women. *International Journal of Behavioral Medicine*, **21**: 511-18.
Jáuregui A, Pratt M, Lamadrid-Figueroa H, et al. 2016. Perceived neighborhood environment and physical activity: the International Physical Activity and Environment Network Adult Study in Mexico. *American Journal of Preventive Medicine*, **51**: 271-79.
Jekielek S, Brown B. 2005. *The transition to adulthood: Characteristics of young adults ages 18 to 24 in America*. Annie E. Casey Foundation, MD: USA.
Jenkinson C, Layte R, Jenkinson D, et al. 1997. A shorter form health survey: can the SF-12 replicate results from the SF-36 in longitudinal studies? *Journal of Public Health*, **19**: 179-86.
Joseph RP, Keller C, Adams MA, Ainsworth BE. 2015. Print versus a culturally-relevant Facebook and text message delivered intervention to promote physical activity in African American women: a randomized pilot trial. *BMC Womens Health*, **15**: 30.
Kaczynski AT, Henderson KA. 2008. Parks and recreation settings and active living: a review of associations with physical activity function and intensity. *Journal of Physical Activity and Health*, **5**: 619-32.
Kahlmeier S, Wijnhoven TM, Alpiger P, et al. 2015. National physical activity recommendations: systematic overview and analysis of the situation in European countries. *BMC Public Health*, **15**: 1412.
Kalak N, Gerber M, Kirov R, et al. 2012. Daily morning running for 3 weeks improved sleep and psychological functioning in healthy adolescents compared with controls. *Journal of Adolescent Health*, **51**: 615-22.
Keating XD, Guan J, Pinero JC, Bridges DM. 2005. A meta-analysis of college students' physical activity behaviors. *Journal of American College Health*, **54**: 116-25.
Kessler RC, Andrews G, Colpe LJ, et al. 2002. Short screening scales to monitor population prevalences and trends in non-specific psychological distress. *Psychological Medicine*, **32**: 959-76.
Kessler RC, Green JG, Gruber MJ, et al. 2010. Screening for serious mental illness in the general population with the K6 screening scale: results from the WHO World Mental Health (WMH) survey initiative. *International Journal of Methods in Psychiatric Research*, **19**: 4-22.
Khalaf A, Ekblom Ö, Kowalski J, et al. 2013. Female university students' physical activity levels and associated factors—a cross-sectional study in southwestern Saudi Arabia. *International Journal of Environmental Research and Public Health*, **10**: 3502-17.
Khan A, Burton N, Trost S. 2017. Patterns and correlates of physical activity in adolescents in Dhaka city, Bangladesh. *Public Health*, **145**: 75-82.
Khan A, Burton NW. 2016. Screen-based behaviors of adolescents in Bangladesh. *Journal of Physical Activity and Health*, **13**: 1156-63.
Khan A, Burton NW. 2017. Is physical inactivity associated with depressive symptoms among adolescents with high screen time? Evidence from a developing country. *Mental Health and Physical Activity*, **12**: 94-99.
Khan A, Uddin R, Burton NW. 2018. Insufficient physical activity in combination with high screen time is associated with adolescents' psychosocial difficulties. *International Health*, **10**: 246-51.
Kilpatrick M, Hebert E, Bartholomew J. 2005. College students' motivation for physical activity: differentiating men's and women's motives for sport participation and exercise. *Journal of American College Health*, **54**: 87-94.
Kline CE. 2014. The bidirectional relationship between exercise and sleep: implications for exercise adherence and sleep improvement. *American Journal of Lifestyle Medicine*, **8**: 375-79.
Konharn K, Santos MP, Ribeiro JC. 2014. Socioeconomic status and objectively measured physical activity in Thai adolescents. *Journal of Physical Activity and Health*, **11**: 712-20.
Korn L, Gonen E, Shaked Y, Golan M. 2013. Health perceptions, self and body image, physical activity and nutrition among undergraduate students in Israel. *PloS One*, **8**: e58543.

Koyanagi A, Stubbs B, Vancampfort D. 2018. Correlates of low physical activity across 46 low- and middle-income countries: a cross-sectional analysis of community-based data. *Preventive Medicine*, **106**: 107-13.
Kredlow MA, Capozzoli MC, Hearon BA, Calkins AW, Otto MW. 2015. The effects of physical activity on sleep: a meta-analytic review. *Journal of Behavioral Medicine*, **38**: 427-49.
Kremer P, Elshaug C, Leslie E, et al. 2014. Physical activity, leisure-time screen use and depression among children and young adolescents. *Journal of Science and Medicine in Sport*, **17**: 183-87.
Kripke DF. 2000. Chronic hypnotic use: deadly risks, doubtful benefit. *Sleep Medicine Reviews*, **4**: 5-20.
Kumar S, Bano S. 2017. Comparison and Analysis of Health Care Delivery Systems: Pakistan versus Bangladesh. *Journal of Hospital & Medical Management*, **3**: 1. doi: 10.4172/2471-9781.100020
Kwan MY, Cairney J, Faulkner GE, Pullenayegum EE. 2012. Physical activity and other health-risk behaviors during the transition into early adulthood: a longitudinal cohort study. *American Journal of Preventive Medicine*, **42**: 14-20.
Lake AA, Townshend T, Alvanides S, Stamp E, Adamson AJ. 2009. Diet, physical activity, sedentary behaviour and perceptions of the environment in young adults. *Journal of Human Nutrition and Dietetics*, **22**: 444-54.
Lakerveld J, Mackenbach J, Horvath E, et al. 2016. The relation between sleep duration and sedentary behaviours in European adults. *Obesity Reviews*, **17**: 62-67.
Lang C, Kalak N, Brand S, et al. 2016. The relationship between physical activity and sleep from mid adolescence to early adulthood. A systematic review of methodological approaches and meta-analysis. *Sleep Medicine Reviews*, **28**: 32-45.
Lee E-Y, Hunter S, Leatherdale ST, Carson V. 2017. Sociodemographic correlates of physical activity and screen time among adolescents in Canada and Guatemala: Results from the COMPASS system. *Global Health Promotion.* doi:10.1177/1757975917710804.
Lee I-M, Shiroma EJ. 2014. Using accelerometers to measure physical activity in large-scale epidemiological studies: issues and challenges. *British Journal of Sports Medicine*, **48**: 197-201.
Lee IM, Buchner DM. 2008. The importance of walking to public health. *Medicine & Science in Sports & Exercise*, **40**: S512-18.
Lee IM, Shiroma EJ, Lobelo F, et al. 2012. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*, **380**: 219-29.
Lee KS, Trost SG. 2006. Physical activity patterns of Singaporean adolescents. *Pediatric Exercise Science*, **18**: 400-14.
Leslie E, Sparling PB, Owen N. 2001. University campus settings and the promotion of physical activity in young adults: lessons from research in Australia and the USA. *Health Education*, **101**: 116-25.
Li M, Fang Q, Li J, et al. 2015. The effect of Chinese traditional exercise-Baduanjin on physical and psychological well-being of college students: a randomized controlled trial. *PloS One*, **10**: e0130544.
Loprinzi PD, Cardinal BJ. 2011. Association between objectively-measured physical activity and sleep, NHANES 2005–2006. *Mental Health and Physical Activity*, **4**: 65-69.
Lund HG, Reider BD, Whiting AB, Prichard JR. 2010. Sleep patterns and predictors of disturbed sleep in a large population of college students. *Journal of Adolescent Health*, **46**: 124-32.
Macniven R, Bauman A, Abouzeid M. 2012. A review of population-based prevalence studies of physical activity in adults in the Asia-Pacific region. *BMC Public Health*, **12**: 41.
Maldonado G, Greenland S. 1993. Simulation study of confounder-selection strategies. *American Journal of Epidemiology*, **138**: 923-36.
Martins RC, Reichert FF, Bielemann RM, Hallal PC. 2017. One-year stability of objectively measured physical activity in young Brazilian adults. *Journal of Physical Activity and Health*, **14**: 208-12.
Martinsen EW. 2008. Physical activity in the prevention and treatment of anxiety and depression. *Nordic Journal of Psychiatry*, **62**: 25-29.

Matthews CE, Chen KY, Freedson PS, et al. 2008. Amount of time spent in sedentary behaviors in the United States, 2003–2004. *American Journal of Epidemiology*, **167**: 875-81.
McAlister AL, Perry CL, Parcel GS. 2008. How individuals, environments, and health behaviors interact: Social cognitive theory. In: Glanz K, Rimer BK, Viswanath K (eds). Health behavior and health education: Theory, research, and practice. Jossey-Bass, CA: USA. pp.169-188.
McArthur LH, Raedeke TD. 2009. Race and sex differences in college student physical activity correlates. *American Journal of Health Behavior*, **33**: 80-90.
McCracken M, Jiles R, Michels Blanck H. 2007. Health behaviors of the young adult U.S. population: Behavioral Risk Factor Surveillance System, 2003. *Preventing Chronic Disease*, **4**: A25.
McLeroy KR, Bibeau D, Steckler A, Glanz K. 1988. An ecological perspective on health promotion programs. *Health Education & Behavior*, **15**: 351-77.
McVeigh JA, Winkler EA, Howie EK, et al. 2016. Objectively measured patterns of sedentary time and physical activity in young adults of the Raine study cohort. *International Journal of Behavioral Nutrition and Physical Activity*, **13**: 41.
Meerlo P, Havekes R, Steiger A. 2015. Chronically restricted or disrupted sleep as a causal factor in the development of depression. In: Meerlo P, Benca RM, Abel T (eds). *Sleep, Neuronal Plasticity and Brain Function.* Springer-Verlag Berlin Heidelberg, Berlin: Germany. pp.459-81.
Melton BF, Bigham LE, Bland HW, Bird M, Fairman C. 2014. Health-related behaviors and technology usage among college students. *American Journal of Health Behavior*, **38**: 510-18.
Mielke GI, Brown WJ, Nunes BP, Silva ICM, Hallal PC. 2017. Socioeconomic correlates of sedentary behavior in adolescents: systematic review and meta-analysis. *Sports Medicine*, **47**: 61-75.
Miles L. 2007. Physical activity and health. *Nutrition Bulletin*, **32**: 314-63.
Ministry of Communication. 2013. Bangladesh National Integrated Multimodal Transport Policy, 2013. Ministry of Communication. The People's Republic of Bangladesh.
Ministry of Health and Family Welfare. 2011. Bangladesh National Health Policy 2011. Ministry of Health and Family Welfare. The People's Republic of Bangladesh.
Mirzaei-Alavijeh M, Soroush A, Nasirzadeh M, et al. 2018. Socio-cognitive determinants of regular physical activity among college students. *World Family Medicine*, **16**: 158-62.
Misra A, Bhardwaj S. 2014. Obesity and the metabolic syndrome in developing countries: focus on South Asians. *Nestlé Nutrition Institute Workshop Series*, **78**: 133-40.
Misra A, Ramchandran A, Jayawardena R, Shrivastava U, Snehalatha C. 2014. Diabetes in South Asians. *Diabetic Medicine*, **31**: 1153-62.
Mohammed G, Md Said S, Ariffin AA, Jusoff K. 2014. Physical inactivity and its associated factors among university students. *IOSR Journal of Dental and Medical Sciences*, **13**: 119-30.
Mohan V, Ruchi V, Rajagopal Gayathri M, et al. 2016. Slowing the diabetes epidemic in the World Health Organization South-East Asia Region: the role of diet and physical activity. *WHO South-East Asia J Public Health*, **5**: 5-16.
Molina-Garcia J, Queralt A, Castillo I, Sallis JF. 2015. Changes in physical activity domains during the transition out of high school: psychosocial and environmental correlates. *Journal of Physical Activity and Health*, **12**: 1414-20.
Moniruzzaman M. Physical activity levels: prevalence and correlates among urban and rural adults of Bangladesh. *Paper presented at 20th IEA World Congress of Epidemiology*, Alaska, USA.
Moniruzzaman M, Ahmed MSAM, Zaman MM. 2017. Physical activity levels and associated socio-demographic factors in Bangladeshi adults: a cross-sectional study. *BMC Public Health*, **17**: 59.
Moniruzzaman M, Mostafa Zaman M, Islalm MS, et al. 2016. Physical activity levels in Bangladeshi adults: results from STEPS survey 2010. *Public health*, **137**: 131-38.
Moore SC, Patel AV, Matthews CE, et al. 2012. Leisure time physical activity of moderate to vigorous intensity and mortality: a large pooled cohort analysis. *PLoS Medicine*, **9**: e1001335.

Musaiger AO, Al-Kandari FI, Al-Mannai M, et al. 2014. Perceived barriers to weight maintenance among university students in Kuwait: the role of gender and obesity. *Environmental Health and Preventive Medicine*, **19**: 207-14.
Nabkasorn C, Miyai N, Sootmongkol A, et al. 2006. Effects of physical exercise on depression, neuroendocrine stress hormones and physiological fitness in adolescent females with depressive symptoms. *European Journal of Public Health*, **16**: 179-84.
Nader PR, Bradley RH, Houts RM, McRitchie SL, O'Brien M. 2008. Moderate-to-vigorous physical activity from ages 9 to 15 years. *Journal of the American Medical Association*, **300**: 295-305.
Nanney MS, Lytle LA, Farbakhsh K, et al. 2015. Weight and weight-related behaviors among 2-year college students. *Journal of American College Health*, **63**: 221-29.
Nantulya VM, Reich MR. 2002. The neglected epidemic: road traffic injuries in developing countries. *British Medical Journal*, **324**: 1139-41.
Narain JP, Garg R, Fric A. 2011. Non-communicable diseases in the South-East Asia region: burden, strategies and opportunities. *National Medical Journal of India*, **24**: 280-87.
National Institute of Population Research and Training - Bangladesh. Bangladesh Demographic and Health Survey (BDHS), Ministry of Health and Family Welfare, Bangladesh. The People's Republic of Bangladesh.
Neumark-Sztainer D, Story M, Hannan PJ, Tharp T, Rex J. 2003. Factors associated with changes in physical activity: a cohort study of inactive adolescent girls. *Archives of Pediatrics & Adolescent Medicine*, **157**: 803-10.
O'Donoghue G, Perchoux C, Mensah K, et al. 2016. A systematic review of correlates of sedentary behaviour in adults aged 18–65 years: a socio-ecological approach. *BMC Public Health*, **16**: 163.
Oltmann S. 2016. Qualitative interviews: a methodological discussion of the interviewer and respondent contexts. *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research.* Article #15.
Owen N, Healy G, Howard B, Dunstan D. 2012. Too much sitting: health risks of sedentary behaviour and opportunities for change. *President's Council on Fitness, Sports & Nutrition*, **13**: 1-11.
Owen N, Healy GN, Matthews CE, Dunstan DW. 2010a. Too much sitting: the population health science of sedentary behavior. *Exercise and Sport Sciences Reviews*, **38**: 105-13.
Owen N, Salmon J, Koohsari MJ, Turrell G, Giles-Corti B. 2014. Sedentary behaviour and health: mapping environmental and social contexts to underpin chronic disease prevention. *British Journal of Sports Medicine*, **48**: 174-77.
Owen N, Sparling PB, Healy GN, Dunstan DW, Matthews CE. 2010b. Sedentary behavior: emerging evidence for a new health risk. *Mayo Clinic Proceedings*, **85**: 1138-41.
Owen N, Sugiyama T, Eakin EE, et al. 2011. Adults' sedentary behavior: determinants and interventions. *American Journal of Preventive Medicine*, **41**: 189-96.
Oyeyemi AL, Adegoke BO, Sallis JF, Oyeyemi AY, De Bourdeaudhuij I. 2012. Perceived crime and traffic safety is related to physical activity among adults in Nigeria. *BMC Public Health*, **12**: 294.
Oyeyemi AL, Adegoke BOA, Oyeyemi AY, Sallis JF. 2011. Perceived environmental correlates of physical activity and walking in African young adults. *American Journal of Health Promotion*, **25**: e10-e19.
Paffenbarger RS, Jr., Blair SN, Lee IM. 2001. A history of physical activity, cardiovascular health and longevity: the scientific contributions of Jeremy N Morris, DSc, DPH, FRCP. *International Journal of Epidemiology*, **30**: 1184-92.
Palacio-Vieira JA, Villalonga-Olives E, Valderas JM, et al. 2008. Changes in health-related quality of life (HRQoL) in a population-based sample of children and adolescents after 3 years of follow-up. *Quality of Life Research*, **17**: 1207-15.
Paluska SA, Schwenk TL. 2000. Physical activity and mental health: current concepts. *Sports Medicine*, **29**: 167-80.
Parra DC, Hoehner CM, Hallal PC, et al. 2011. Perceived environmental correlates of physical activity for leisure and transportation in Curitiba, Brazil. *Preventive Medicine*, **52**: 234-38.
Pate RR, O'Neill JR, Lobelo F. 2008. The evolving definition of "sedentary". *Exercise and Sport Sciences Reviews*, **36**: 173-78.

Patel V, Flisher AJ, Hetrick S, McGorry P. 2007. Mental health of young people: a global public-health challenge. *Lancet*, **369**: 1302-13.
Patrick H, Hennessy E, McSpadden K, Oh A. 2013. Parenting styles and practices in children's obesogenic behaviors: scientific gaps and future research directions. *Childhood Obesity*, **9**: S73-86.
Patterson R, McNamara E, Tainio M, et al. 2018. Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *European Journal of Epidemiology*, **33**: 811-29
Pedišić Ž, Dumuid D, Olds TS. 2017. Integrating sleep, sedentary behaviour, and physical activity research in the emerging field of time-use epidemiology: definitions, concepts, statistical methods, theoretical framework, and future directions. *Kinesiology*, **49**: 252-69.
Pedisic Z, Greblo Z, Phongsavan P, Milton K, Bauman AE. 2015. Are total, intensity-and domain-specific physical activity levels associated with life satisfaction among university students? *PloS One*, **10**: e0118137.
Peltzer K, Pengpid S. 2014. Sitting time and its associated factors in university students from 18 low, middle and emerging economy countries. *African Journal for Physical Health Education, Recreation and Dance*, **20**: 1379-89.
Peltzer K, Pengpid S, Apidechkul T. 2014. Heavy Internet use and its associations with health risk and health-promoting behaviours among Thai university students. *International Journal of Adolescent Medicine and Health*, **26**: 187-94.
Pengpid S, Peltzer K. 2013. Physical inactivity and associated factors among university students in South Africa. *African Journal for Physical Health Education, Recreation and Dance*, **19**: 143-53.
Pengpid S, Peltzer K, Kassean H, et al. 2015. Physical inactivity and associated factors among university students in 23 low-, middle- and high-income countries. *International Journal of Public Health*, **60**: 539-49.
Perogamvros L, Schwartz S. 2013. Sleep and emotional functions. In: Meerlo P, Benca RM, Abel T (eds). *Sleep, Neuronal Plasticity and Brain Function.* Springer-Verlag Berlin Heidelberg, Berlin: Germany. pp.411-31.
Poomsrikaew O, Berger BE, Kim MJ, Zerwic JJ. 2012. Age and gender differences in social-cognitive factors and exercise behavior among Thais. *Western Journal of Nursing Research*, **34**: 245-64.
Prince SA, Reed JL, McFetridge C, Tremblay MS, Reid RD. 2017. Correlates of sedentary behaviour in adults: a systematic review. *Obesity Reviews*, **18**: 915-35.
Proper KI, Singh AS, van Mechelen W, Chinapaw MJM. 2011. Sedentary behaviors and health outcomes among adults: a systematic review of prospective studies. *American Journal of Preventive Medicine*, **40**: 174-82.
Pucher J, Dijkstra L. 2003. Promoting safe walking and cycling to improve public health: lessons from the Netherlands and Germany. *American Journal of Public Health*, **93**: 1509-16.
Rabe-Hesketh S, Skrondal A, Pickles A. 2002. Reliable estimation of generalized linear mixed models using adaptive quadrature. *Stata Journal*, **2**: 1-21.
Rachlin H, Kagel JH, Battalio RC. 1980. Substitutability in time allocation. *Psychological Review*, **87**: 355-74.
Rahim MA, Hussain A, Azad Khan AK, et al. 2007. Rising prevalence of type 2 diabetes in rural Bangladesh: a population based study. *Diabetes Research and Clinical Practice*, **77**: 300-305.
Rahman MA, Meerjady SF, Akter SFU, Hossain S, Mascie-Taylor CGN. 2004. Behavioural risk factors of non-communicable diseases in Bangladesh. Institute of Epidemiology, Disease Control and Research (IEDCR), Dhaka: Bangladesh.
Ranasinghe C, Ranasinghe P, Jayawardena R, Misra A. 2013. Physical activity patterns among South-Asian adults: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, **10**: 116.
Ranasinghe G, Amarawickrama S, Rathnayake R. 2016. A Study to Compare the Level of Walkability in Two Urban Neighborhoods of Sri Lanka. *International Journal of Engineering Research and General Science*, **4**: 6-13.
Rangul V, Bauman A, Holmen TL, Midthjell K. 2012. Is physical activity maintenance from adolescence to young adulthood associated with reduced CVD risk factors, improved

mental health and satisfaction with life: the HUNT Study, Norway. *International Journal of Behavioral Nutrition and Physical Activity*, **9**: 144.
Raudsepp L, Viira R. 2008. Changes in physical activity in adolescent girls: a latent growth modelling approach. *Acta Paediatrica*, **97**: 647-52.
Rayward AT, Duncan MJ, Brown WJ, Plotnikoff RC, Burton NW. 2017. A cross-sectional cluster analysis of the combined association of physical activity and sleep with sociodemographic and health characteristics in mid-aged and older adults. *Maturitas*, **102**: 56-61.
Rebar AL, Stanton R, Geard D, et al. 2015. A meta-meta-analysis of the effect of physical activity on depression and anxiety in non-clinical adult populations. *Health Psychology Review*, **9**: 366-78.
Reiner M, Niermann C, Jekauc D, Woll A. 2013. Long-term health benefits of physical activity–a systematic review of longitudinal studies. *BMC Public Health*, **13**: 813.
Rhodes RE, Blanchard CM. 2011. Time displacement and confidence to participate in physical activity. *International Journal of Behavioral Medicine*, **18**: 229-34.
Rhodes RE, Janssen I, Bredin SS, Warburton DE, Bauman A. 2017. Physical activity: Health impact, prevalence, correlates and interventions. *Psychology & Health*, **32**: 942-75.
Rhodes RE, Mark RS, Temmel CP. 2012. Adult sedentary behavior: a systematic review. *American Journal of Preventive Medicine*, **42**: e3-e28.
Richardson A, King S, Garrett R, Wrench A. 2012. Thriving or just surviving? Exploring student strategies for a smoother transition to university. A Practice Report. *International Journal of the First Year in Higher Education*, **3**: 87-93.
Riley L, Guthold R, Cowan M, et al. 2016. The World Health Organization STEPwise approach to noncommunicable disease risk-factor surveillance: methods, challenges, and opportunities. *American Journal of Public Health*, **106**: 74-78.
Romaguera D, Tauler P, Bennasar M, et al. 2011. Determinants and patterns of physical activity practice among Spanish university students. *Journal of Sports Sciences*, **29**: 989-97.
Rosenstock IM, Strecher VJ, Becker MH. 1988. Social learning theory and the health belief model. *Health Education & Behavior*, **15**: 175-83.
Rovniak L, Anderson E, Winett R, Stephens R. 2002. Social cognitive determinants of physical activity in young adults: a prospective structural equation analysis. *Annals of Behavioral Medicine*, **24**: 149-56.
Saad FM. 2014. The underrepresentation of Muslim women in Higher Education: a case study of the causes and opportunities for change in Uganda. Doctoral dissertation, University of Leicester.
Saelens BE, Sallis JF, Frank LD. 2003. Environmental correlates of walking and cycling: Findings from the transportation, urban design, and planning literatures. *Annals of Behavioral Medicine*, **25**: 80-91.
Sallis JF. 2000. Age-related decline in physical activity: a synthesis of human and animal studies. *Medicine & Science in Sports & Exercise*, **32**: 1598-600.
Sallis JF. 2009. Measuring physical activity environments: a brief history. *American Journal of Preventive Medicine*, **36**: S86-92.
Sallis JF, Bull F, Guthold R, et al. 2016. Progress in physical activity over the Olympic quadrennium. *Lancet*, **388**: 1325-36.
Sallis JF, Floyd MF, Rodriguez DA, Saelens BE. 2012. Role of built environments in physical activity, obesity, and cardiovascular disease. *Circulation*, **125**: 729-37.
Sallis JF, Grossman RM, Pinski RB, Patterson TL, Nader PR. 1987. The development of scales to measure social support for diet and exercise behaviors. *Preventive Medicine*, **16**: 825-36.
Sallis JF, Hovell MF, Hofstetter CR, et al. 1989. A multivariate study of determinants of vigorous exercise in a community sample. *Preventive Medicine*, **18**: 20-34.
Sallis JF, Owen N. 1998. *Physical activity and behavioral medicine*. SAGE Publications, CA: USA.
Sallis JF, Owen N, Fisher EB. 2008. *Ecological models of health behavior*. Jossey-Bass, CA: USA.
Sanchez-Villegas A, Ara I, Guillen-Grima F, et al. 2008. Physical activity, sedentary index, and mental disorders in the SUN cohort study. *Medicine and Science in Sports and Exercise*, **40**: 827-34.
Saquib J, Saquib N, Stefanick ML, et al. 2016. Sex differences in obesity, dietary habits, and physical activity among urban middle-class Bangladeshis. *International Journal of Health Sciences*, **10**: 363-72.

Sarwar MR. 2015. Bangladesh Health service delivery: innovative ngo and private sector partnerships. *IDS Bulletin*, **46**: 17-28.
Sattelmair J, Pertman J, Ding EL, et al. 2011. Dose response between physical activity and risk of coronary heart disease: a meta-analysis. *Circulation*, **124**: 789-95.
Schmid D, Leitzmann M. 2014. Physical activity epidemiology. In: Ahrens W, Pigeot I (eds). *Handbook of Epidemiology.* Springer, NY: USA. pp.1927-2002.
Schuch FB, Vancampfort D, Firth J, et al. 2018. Physical activity and incident depression: a meta-analysis of prospective cohort studies. *American Journal of Psychiatry*, **175**: 631-48.
Schwarzer R, Renner B. 2009. Health-specific self-efficacy scales. *Freie Universität Berlin*.
Seo D-C, Torabi MR, Jiang N, Fernandez-Rojas X, Park B-H. 2009. Correlates of college students' physical activity: cross-cultural differences. *Asia-Pacific Journal of Public Health*, **21**: 421-32.
Shaheen S, Guzman S, Zhang H. 2010. Bikesharing in Europe, the Americas, and Asia: past, present, and future. *Transportation Research Record: Journal of the Transportation Research Board, No. 2143*. pp.159-67.
Shumi S, Zuidgeest M, Martinez J, Efroymson D, van Maarseveen M. 2015. Understanding the relationship between walkability and quality-of-life of women garment workers in Dhaka, Bangladesh. *Applied Research in Quality of Life*, **10**: 263-87.
Shuval K, Weissblueth E, Brezis M, Araida A, DiPietro L. 2009. Individual and socioecological correlates of physical activity among Arab and Jewish college students in Israel. *Journal of Physical Activity and Health*, **6**: 306-14.
Siegel KR, Patel SA, Ali MK. 2014. Non-communicable diseases in South Asia: contemporary perspectives. *British Medical Bulletin*, **111**: 31-44.
Simons D, Rosenberg M, Salmon J, et al. 2015. Psychosocial moderators of associations between life events and changes in physical activity after leaving high school. *Preventive Medicine*, **72**: 30-33.
Smith AL, Biddle S. 2008. *Youth physical activity and sedentary behavior: challenges and solutions*. Human Kinetics, IL: USA.
Smith L, Gardner B, Fisher A, Hamer M. 2015. Patterns and correlates of physical activity behaviour over 10 years in older adults: prospective analyses from the English Longitudinal Study of Ageing. *BMJ Open*, **5**: e007423.
Sreeramareddy C, Kutty N, Jabbar M, Boo N. 2012. Physical activity and associated factors among young adults in Malaysia: an online exploratory survey. *BioScience Trends*, **6**: 103-09.
Stavrakakis N, de Jonge P, Ormel J, Oldehinkel AJ. 2012. Bidirectional prospective associations between physical activity and depressive symptoms. The TRAILS Study. *Journal of Adolescent Health*, **50**: 503-08.
Stierlin AS, De Lepeleere S, Cardon G, et al. 2015. A systematic review of determinants of sedentary behaviour in youth: a DEDIPAC-study. *International Journal of Behavioral Nutrition and Physical Activity*, **12**: 133.
Ströhle A. 2009. Physical activity, exercise, depression and anxiety disorders. *Journal of Neural Transmission*, **116**: 777-84.
Ströhle A, Höfler M, Pfister H, et al. 2007. Physical activity and prevalence and incidence of mental disorders in adolescents and young adults. *Psychological Medicine*, **37**: 1657-66.
Stubbe JH, De Moor MHM, Boomsma DI, De Geus EJC. 2007. The association between exercise participation and well-being: a co-twin study. *Preventive Medicine*, **44**: 148-52.
Sugiyama T, Cerin E, Owen N, et al. 2014. Perceived neighbourhood environmental attributes associated with adults′ recreational walking: IPEN Adult study in 12 countries. *Health & Place*, **28**: 22-30.
Swift D, Johannsen NM, Church T. 2016. Physical Activity Programs. In: Mechanick JI, Kushner RF (eds). *Lifestyle Medicine: A Manual for Clinical Practice.* Springer International Publishing. pp.121-27.
SWOV Institute for Road Safety Research. 2012. SWOV Fact sheet: Subjective safety in traffic. SWOV Institute for Road Safety Research, The Netherlands.
Teychenne M, Abbott G, Lamb KE, Rosenbaum S, Ball K. 2017. Is the link between movement and mental health a two-way street? Prospective associations between physical activity, sedentary behaviour and depressive symptoms among women living in socioeconomically disadvantaged neighbourhoods. *Preventive Medicine*, **102**: 72-78.

Thompson PD, Buchner D, Piña IL, et al. 2003. Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease: a statement from the Council on Clinical Cardiology (Subcommittee on Exercise, Rehabilitation, and Prevention) and the Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity). *Circulation*, **107**: 3109-16.

Thorp AA, Owen N, Neuhaus M, Dunstan DW. 2011. Sedentary behaviors and subsequent health outcomes in adults a systematic review of longitudinal studies, 1996-2011. *American Journal of Preventive Medicine*, **41**: 207-15.

Thrift AP, Xiao L, Patel SR, et al. 2014. Effects of physical activity on melatonin levels in previously sedentary men and women. *Cancer Epidemiology, Biomarkers & Prevention* **23**: 1696-99.

Towne SD, Ory MG, Smith ML, et al. 2017. Accessing physical activity among young adults attending a university: the role of sex, race/ethnicity, technology use, and sleep. *BMC Public Health*, **17**: 721.

Tremblay MS, Aubert S, Barnes JD, et al. 2017. Sedentary behavior research network (SBRN)–terminology consensus project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity*, **14**: 75.

Tremblay MS, Colley RC, Saunders TJ, Healy GN, Owen N. 2010. Physiological and health implications of a sedentary lifestyle. *Applied Physiology, Nutrition, and Metabolism*, **35**: 725-40.

Tremblay MS, Warburton DER, Janssen I, et al. 2011. New Canadian physical activity guidelines. *Applied Physiology, Nutrition, and Metabolism*, **36**: 36-46.

Tucker T. 2011. What influences young adults' decision to adopt new technology? *The Elon Journal of Undergraduate Research in Communications*, **2**: 147-57.

Tyson P, Wilson K, Crone D, Brailsford R, Laws K. 2010. Physical activity and mental health in a student population. *Journal of Mental Health*, **19**: 492-99.

U.S. Department of Health and Human Services. 1998. Physical activity and health: a report of the Surgeon General. U.S. Department of Health and Human Services/Centers for Disease Control and Prevention/National Center for Chronic Disease Prevention and Health Promotion.

Uddin R, Khan A, Burton NW. 2017. Prevalence and sociodemographic patterns of physical activity among Bangladeshi young adults. *Journal of Health, Population and Nutrition*, **36**: 31.

UNICEF. 2010. Women and girls in Bangladesh. UNICEF Bangladesh.

United Nations. 2009. World Population Prospects: The 2008 Revision, Highlights, Working Paper No. ESA/P/WP.210 United Nations, Department of Economic and Social Affairs, Population Division.

United Nations. 2010. The World's Women 2010: Trends and Statistics. United Nations Statistics Division, The United Nations.

United Nations. 2016. United Nations Demographic Yearbook. 66 edn. The United Nations.

United Nations Educational, Scientific and Cultural Organization. n.d. Bangladesh: education and literacy. UNESCO Institute of Statistics.

University Grants Comission of Bangladesh. n.d. University Grants Comission of Bangladesh: list of universities. Available at: http://www.ugc.gov.bd/en/home/university [Accessed: 23 Mar 2015].

Van de Mortel TF. 2008. Faking it: social desirability response bias in self-report research. *Australian Journal of Advanced Nursing*, **25**: 40-48.

van den Berg P, Paxton SJ, Keery H, et al. 2007. Body dissatisfaction and body comparison with media images in males and females. *Body Image*, **4**: 257-68.

Van der Ploeg HP, Chey T, Korda RJ, Banks E, Bauman A. 2012. Sitting time and all-cause mortality risk in 222 497 Australian adults. *Archives of Internal Medicine*, **172**: 494-500.

Van Dyck D, De Bourdeaudhuij I, Deliens T, Deforche B. 2015. Can changes in psychosocial factors and residency explain the decrease in physical activity during the transition from high school to college or university? *International Journal of Behavioral Medicine*, **22**: 178-86.

Vélez JC, Souza A, Traslaviña S, et al. 2013. The epidemiology of sleep quality and consumption of stimulant beverages among Patagonian Chilean College Students. *Sleep Disorders*, **2013**: 910104.

Voelker R. 2004. Stress, sleep loss, and substance abuse create potent recipe for college depression. *Journal of the American Medical Association*, **291**: 2177-79.
Wanner M, Hartmann C, Pestoni G, et al. 2017. Validation of the Global Physical Activity Questionnaire for self-administration in a European context. *BMJ Open Sport & Exercise Medicine*, **3**: e000206.
Warburton DE, Charlesworth S, Ivey A, Nettlefold L, Bredin SS. 2010. A systematic review of the evidence for Canada's Physical Activity Guidelines for Adults. *International Journal of Behavioral Nutrition and Physical Activity*, **7**: 39.
Wasay M, Khatri IA, Kaul S. 2014. Stroke in South Asian countries. *Nature Reviews Neurology*, **10**: 135-43.
WBB-Trust. 2015. Parks and playgrounds in Dhaka: taking stock and moving forward. Work for a Better Bangladesh (WBB Trust).
Weaver E, Gradisar M, Dohnt H, Lovato N, Douglas P. 2010. The effect of presleep video-game playing on adolescent sleep. *Journal of Clinical Sleep Medicine*, **6**: 184-89.
Wen CP, Wai JPM, Tsai MK, et al. 2011. Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. *Lancet*, **378**: 1244-53.
WHO. Global Health Estimates: Deaths, disability-adjusted life year (DALYs), years of life lost (YLL) and years lost due to disability (YLD) by cause, age, and sex: 2000–2012. World Health Organization.
Wijndaele K, Brage S, Besson H, et al. 2010. Television viewing time independently predicts all-cause and cardiovascular mortality: the EPIC Norfolk study. *International Journal of Epidemiology*, **40**: 150-59.
Wilmot EG, Edwardson CL, Achana FA, et al. 2012. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia*, **55**: 2895-905.
Win AM, Yen LW, Tan KH, et al. 2015. Patterns of physical activity and sedentary behavior in a representative sample of a multi-ethnic South-East Asian population: a cross-sectional study. *BMC Public Health*, **15**: 318.
Wingood GM, Di Clemente RJ. 2002. The use of psychosocial models for guiding the design and implementation of HIV prevention interventions. In: Gibney L, Di Clemente RJ, Vermund SH (eds). *Preventing HIV in Developing Countries.* Springer, MA: USA. pp.187-204.
World Bank. 2015. World Bank update says 10 countries move up in income bracket. Available at: http://www.worldbank.org/en/news/press-release/2015/07/01/new-world-bank-update-shows-bangladesh-kenya-myanmar-and-tajikistan-as-middle-income-while-south-sudan-falls-back-to-low-income. [Accessed: 19 Aug. 2015].
World Health Organization. 1986. The Ottawa Charter for Health Promotion. Available at: www.crrps.org/download/OttawaCharter.pdf. [Accessed: 13 Apr. 2015].
World Health Organization. 2005. Constitutions of the World Health Organization. Available at: https://www.who.int/governance/eb/who_constitution_en.pdf. [Accessed: 11 May 2015].
World Health Organization. 2010. Global recommendations on physical activity for health. World Health Organization, Geneva: Switzerland.
World Health Organization. 2011. Noncommunicable diseases in the South-East Asia Region: situation and response. World Health Organization Regional Office for South-East Asia.
World Health Organization. 2011. Non-Communicable Disease Risk Factor Survey Bangladesh, 2010. World Health Organization.
World Health Organization. 2012. Global Physical Activity Questionnaire (GPAQ) Analysis Guide. World Health Organization, Geneva: Switzerland.
World Health Organization. 2014. Global School-based Student Health Survey Bangladesh 2014 Fact Sheet. World Health Organization.
World Health Organization. n.d. Global Health Observatory (GHO) data: prevalence of insufficient physical activity. Available at: https://www.who.int/gho/ncd/risk_factors/physical_activity_text/en/. [Accessed: 8 May 2015].
World Health Organization. n.d.-a. Adolescents and mental health. Avialable at: http://www.who.int/maternal_child_adolescent/topics/adolescence/mental_health/en/. [Accessed: 12 Jul. 2017].

World Health Organization. n.d.-b. Global Database on Body Mass Index: BMI classification. WHO. Available at: http://www.assessmentpsychology.com/icbmi.htm. [Accessed: 9 May 2018]
World Health Organization. n.d.-c. Global Physical Activity Surveillance. Available at: https://www.who.int/ncds/surveillance/steps/GPAQ/en/. [Accessed: 28 Sep. 2017].
World Health Organization. n.d.-d. Health topics: Physical activity. Available at: http://www.who.int/topics/physical_activity/en/. [Accessed: 8 May 2016]
Wu X, Tao S, Zhang S, et al. 2016. Impact of screen time on mental health problems progression in youth: a 1-year follow-up study. *BMJ Open*, **6**: e011533.
Wu X, Tao S, Zhang Y, Zhang S, Tao F. 2015. Low physical activity and high screen time can increase the risks of mental health problems and poor sleep quality among Chinese college students. *PloS One*, **10**: e0119607.
Wyatt JK, Dijk D-J, Cecco AR-D, Ronda JM, Czeisler CA. 2006. Sleep-facilitating effect of exogenous melatonin in healthy young men and women is circadian-phase dependent. *Sleep*, **29**: 609-18.
Xi B, He D, Zhang M, Xue J, Zhou D. 2014. Short sleep duration predicts risk of metabolic syndrome: a systematic review and meta-analysis. *Sleep Medicine Reviews*, **18**: 293-97.
Yahia N, Wang D, Rapley M, Dey R. 2015. Assessment of weight status, dietary habits and beliefs, physical activity, and nutritional knowledge among university students. *Perspectives in Public Health*, **136**: 231-44
Yang P-Y, Ho K-H, Chen H-C, Chien M-Y. 2012. Exercise training improves sleep quality in middle-aged and older adults with sleep problems: a systematic review. *Journal of Physiotherapy*, **58**: 157-63.
Yang Y, Shin JC, Li D, An R. 2016. Sedentary behavior and sleep problems: A systematic review and meta-analysis. *International Journal of Behavioral Medicine*, **24**: 481–92.
Yasunaga A, Kawano Y, Kamahori Y, Noguchi K. 2014. Individual and environmental factors related to stage of change in exercise behavior: a cross-sectional study of female japanese undergraduate students. *Journal of Physical Activity and Health*, **11**: 62-67.
Youngstedt SD. 2005. Effects of exercise on sleep. *Clinics in Sports Medicine*, **24**: 355-65.
Yuan C, Lv J, VanderWeele TJ. 2013. An assessment of health behavior peer effects in Peking university dormitories: A randomized cluster-assignment design for interference. *PloS One*, **8**: e75009.
Zaman MM, Bhuiyan MR, Karim MN, et al. 2015. Clustering of non-communicable diseases risk factors in Bangladeshi adults: An analysis of STEPS survey 2013. *BMC Public Health*, **15**: 659.
Zhai L, Zhang Y, Zhang D. 2015. Sedentary behaviour and the risk of depression: a meta-analysis. *British journal of Sports Medicine*, **49**: 705-09.
Zickuhr K. 2011. Generations and their gadgets. *Pew Internet & American Life Project*, **20**.
Zochil ML, Thorsteinsson EB. 2017. Exploring poor sleep, mental health, and help-seeking intention in university students. *Australian Journal of Psychology*, **70**: 41-47.

Appendix A: Ethics approval

A1: The University of Queensland Institutional Human Research Ethics Approval (Original)

THE UNIVERSITY OF QUEENSLAND

Institutional Human Research Ethics Approval

Project Title:	Health and Wellbeing of University Students of Dhaka City, Bangladesh: a Longitudinal Study
Chief Investigator:	Mr Riaz Uddin
Supervisor:	Dr Asad Khan, Dr Nicola Burton
Co-Investigator(s):	Dr Asad Khan, Dr Nicola Burton
School(s):	SHRS; HMNS
Approval Number:	2015000860
Granting Agency/Degree:	PhD
Duration:	31st May 2017

Comments/Conditions:

Expedited Review - Low Risk

Note: if this approval is for amendments to an already approved protocol for which a UQ Clinical Trials Protection/Insurance Form was originally submitted, then the researchers must directly notify the UQ Insurance Office of any changes to that Form and Participant Information Sheets & Consent Forms as a result of the amendments, before action.

Name of responsible Committee:
Behavioural & Social Sciences Ethical Review Committee
This project complies with the provisions contained in the *National Statement on Ethical Conduct in Human Research* and complies with the regulations governing experimentation on humans.

Name of Ethics Committee representative:
Associate Professor John McLean
Chairperson
Behavioural & Social Sciences Ethical Review Committee

Signature _____ Date 1/6/2015

A2: The University of Queensland Institutional Human Research Ethics Approval (Amendment 1)

THE UNIVERSITY OF QUEENSLAND

Institutional Human Research Ethics Approval

Project Title:	Health and Wellbeing of University Students of Dhaka City, Bangladesh: a Longitudinal Study - 31/07/2015 - AMENDMENT
Chief Investigator:	Mr Riaz Uddin
Supervisor:	Dr Asad Khan, Dr Nicola Burton
Co-Investigator(s):	Dr Asad Khan, Dr Nicola Burton
School(s):	SHRS; HMNS
Approval Number:	2015000860
Granting Agency/Degree:	PhD
Duration:	31st May 2017

Comments/Conditions:

Note: if this approval is for amendments to an already approved protocol for which a UQ Clinical Trials Protection/Insurance Form was originally submitted, then the researchers must directly notify the UQ Insurance Office of any changes to that Form and Participant Information Sheets & Consent Forms as a result of the amendments, before action.

Name of responsible Committee:
Behavioural & Social Sciences Ethical Review Committee
This project complies with the provisions contained in the *National Statement on Ethical Conduct in Human Research* and complies with the regulations governing experimentation on humans.

Name of Ethics Committee representative:
Associate Professor John McLean
Chairperson
Behavioural & Social Sciences Ethical Review Committee

Signature _____ Date 3/8/2015

A3: The University of Queensland Institutional Human Research Ethics Approval (Amendment 2)

THE UNIVERSITY OF QUEENSLAND

Institutional Human Research Ethics Approval

Project Title:	Health and Wellbeing of University Students of Dhaka City, Bangladesh: a Longitudinal Study - 29/09/2016 - AMENDMENT
Chief Investigator:	Mr Riaz Uddin
Supervisor:	Dr Asad Khan, Dr Nicola Burton
Co-Investigator(s):	Dr Asad Khan, Dr Nicola Burton
School(s):	SHRS; HMNS
Approval Number:	2015000860
Granting Agency/Degree:	PhD
Duration:	31st May 2017

Comments/Conditions:

- Questionnaire – Wave 2, 30/09/2016
- Participant Information Sheet – Follow-up Survey 2016, 30/09/2016

Note: if this approval is for amendments to an already approved protocol for which a UQ Clinical Trials Protection/Insurance Form was originally submitted, then the researchers must directly notify the UQ Insurance Office of any changes to that Form and Participant Information Sheets & Consent Forms as a result of the amendments, before action.

Name of responsible Committee:
University of Queensland Human Research Ethics Committee B
This project complies with the provisions contained in the *National Statement on Ethical Conduct in Human Research* and complies with the regulations governing experimentation on humans.

Name of Ethics Committee representative:
Dr. Frederick Khafagi
Chairperson
University of Queensland Human Research Ethics Committee
Registration: EC00457

Signature _____ Date 21/10/2016

Appendix B: Wave 1 survey materials

B1: Wave 1 participant information sheet

Physical activity of university students of Dhaka, Bangladesh

Participant Information Sheet

Investigators

Mr Riaz Uddin, PhD Student, School of Health & Rehabilitation Sciences, The University of Queensland, Australia
Dr Nicola Burton, Senior Research Fellow, School of Movement and Nutrition Sciences, The University of Queensland, Australia
Dr Asad Khan, Senior Lecturer, School of Health & Rehabilitation Sciences, The University of Queensland, Australia

What is the study about?

Physical activity means movement of the body that causes an increase in breathing and/or heart rate, and includes things like sport, exercise, competitive or friendly games, walking and bicycling. It is one component of human behaviour that has impact on an individual's health and wellbeing. Though it has been widely studied in many developed countries, there is no information on physical activity participation of young adults, like university students, in Bangladesh. The present study aims to examine different aspects of physical activity of university students (aged 18-24 years) in Dhaka city over a period of two years.

What is involved?

This research project is a part of PhD study of Mr Uddin at the University of Queensland, Australia. This project is a longitudinal study with two waves; Wave One (baseline) will be conducted in this year (2015) and Wave Two (follow-up) will be at around the same time next year (2016). If you agree to participate in both the waves, we will request you to give your consent by ticking the consent statement and signing the consent form. We will then ask you to complete a questionnaire, which takes around 30 to 40 minutes to complete. The questionnaire asks about your physical and psychological health, physical activity, dietary habits, as well as some socio-demographics such as age, education, and living situation. In a year time, you will be requested to participate in a follow-up survey (a shorter version of the baseline survey), either online or face-to-face.

Are there any risks or benefits?

We do not anticipate any risk associated with participating in this study. Filling out the questionnaire offers you an opportunity to reflect on your own individual experiences about physical activity. You are the best person to represent your age group to inform people about physical activity behaviour

of university students in Bangladesh. The obtained information will help us to develop a better understanding of different key aspects of physical activity of university students of Bangladesh. This in turn will be useful to develop strategies to promote healthy and active lifestyles of young adults of this country.

Your participation and privacy

Participation in this study is completely voluntary. If you do not wish to be part of the study, you can withdraw at any stage. All information you provide will be anonymous, confidential and kept in locked storage. The collected information will be used to write thesis report of Mr Uddin as a part of his PhD program and in possible journal or other scholarly publications. Your name will never be used in any outcome of this study, neither in the PhD thesis nor in any publications. We will not identify individuals in any reports, and only summary data will be reported. Only the research team will have access to the data.

Questions?

If you have any questions regarding this project, you can contact Mr Riaz Uddin on mobile 01680106009 or by email: riaz.uddin@uq.net.au. This study adheres to the Guidelines of the ethical review process of The University of Queensland, Australia. Whilst you are free to discuss your participation in this study with project staff, if you would like to speak to an officer of the University of Queensland not involved in the study, you may contact the Ethics Officer on +61 7 3365 3924 [Australia] or by email: humanethics@research.uq.edu.au.

B2: Consent form

Physical activity of university students of Dhaka, Bangladesh

Investigators: Riaz Uddin, Nicola Burton and Asad Khan, The University of Queensland, Australia

Consent Form

I, the undersigned, do hereby acknowledge that I have been given the *information sheet* about "*Physical activity of university students of Dhaka, Bangladesh*" study, which is conducted by Mr Riaz Uddin as a part of his PhD program at the University of Queensland, Australia. I understand that by giving my consent to participate in the study, I agree to participate in this survey and in a follow-up survey in a year time (2016), either online or face-to-face.

I understand that my information will be confidential and that there will be no personal identification in the data that I agree to allow to be used in the study. I also understand that there are no potential risks or burdens associated with participation in this study. I understand that my participation in this research is completely voluntary and I am free to refuse to participate or withdraw from this study at any time.

Identification code: I am creating my own identification code, which is identifiable only to me. I understand that this code will allow the researchers to match Wave 1 and Wave 2 surveys while protecting my anonymity.

i) Write the **FIRST 3 LETTERS** of father's last/family name (e.g., Mostafa = MOS)
ii) Write the **FIRST 3 LETTERS** of mother's last/family name (e.g., Begum = BEG)
iii) Write the **DAY OF YOUR BIRTH** (if you were born on the 19th, write 19)
iv) Write **NUMERICALLY** your **MONTH OF BIRTH** (if you were born in February, write 02)

This *example code* would look like this:	M	O	S	-	B	E	G	-	1	9	-	0	2
Now please write your **own code** here:				-				-			-		

I understand that the following information provided by me will only be used to contact me for the follow-up study, if necessary, and I am happy to be contacted by email/mobile for the purpose of the study.

Year (Please tick): 1st ☐ 2nd ☐ 3rd ☐ 4th ☐

Student ID: ……..

Mobile: ……..

Email: ……..

By signing below I am indicating my consent to participate in this research. I understand that the data collected from my participation will be used primarily for a PhD thesis, and will also be used in summary form for journal or other scholarly publications, and I consent for it to be used in that manner.

☐ **I have read and understood the information sheet about the project and I hereby give consent for myself to participate in this survey (2015) and in the follow-up survey (2016).**

Please write your name _____

Please sign your name _____ Date _____

Physical Activity of University Students of Dhaka, Bangladesh

Please write your own identification code here (the SAME CODE as in the consent form):

			-				-			-		

Physical activity means movement of the body and includes things like exercise, sports, swimming, walking, cycling.

Sedentary activities include works, which cause LITTLE or NO movement (e.g., sitting at a desk, travelling in car, bus, reading, working on a computer, watching television)




Moderate-intensity activities require moderate physical effort and causes SMALL INCREASES in breathing or heart rate (e.g., playing cricket, golf, slow swimming)




Vigorous-intensity activities require hard physical effort and cause LARGE INCREASES in breathing or heart rate (e.g., athletics, competitive sports- playing football, basketball)



WHO Global Physical Activity Questionnaire (GPAQ)

Q1. The following questions ask you about the time you spend doing different types of physical activity in a **TYPICAL WEEK**. Please answer these questions even if you do not consider yourself to be a physically active person.

Think first about the time you spend doing work. Think of work as the things that you have to do such as paid or unpaid work, **STUDY/TRAINING**, household chores, harvesting food/crops, seeking employment.

In answering the following questions ***'vigorous-intensity activities'*** are activities that require hard physical effort and cause large increases in breathing or heart rate, '***moderate-intensity activities***' are activities that require moderate physical effort and cause small increases in breathing or heart rate.

	Questions	Response	
Activity at work/study			
Vigorous intensity activities at work/study			
A	Does your work **(including STUDY/TRAINING)** involve vigorous-intensity activity that causes large increases in breathing or heart rate like carrying or lifting heavy loads, digging or construction work for at least 10 minutes continuously?	Yes No	1 2 *If No, go to D*
B	In a typical week, on how many days do you do vigorous-intensity activities as part of your work?	Number of days	⌊__⌋
C	How much time do you spend doing vigorous-intensity activities **at work on a typical day**?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins
Moderate intensity activities at work/study			
D	Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as **walking to attend classes** or carrying light loads for at least 10 minutes continuously?	Yes No	1 2 *If No, go to G*
E	In a typical week, on how many days do you do moderate-intensity activities as part of your work?	Number of days	⌊__⌋
F	How much time do you spend doing moderate-intensity activities **at work on a typical day**?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins
Travel to and from places			
The next questions **exclude the physical activities at work/study that you have already mentioned**. Now I would like to ask you about the usual way you travel to and from places. For example to work, for shopping, to market, to place of worship.			
G	Do you walk or use a bicycle for at least 10 minutes continuously to get to and from places?	Yes No	1 2 *If No, go to J*
H	In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?	Number of days	⌊__⌋
I	How much time do you spend **walking or bicycling for travel on a typical day**?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins

Recreational activities

The next questions **exclude the work/study and transport activities** that you have already mentioned.
Now I would like to ask you about sports, fitness and recreational activities (leisure time activities).

Vigorous intensity activities during recreational time

J	Do you do any vigorous-intensity sports, fitness or recreational (leisure) activities that cause large increases in breathing or heart rate like (running or playing football) for at least 10 minutes continuously?	Yes No	1 2 *If No, go to M*
K	In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (*leisure*) activities?	Number of days	⌊__⌋
L	How much time do you spend doing **vigorous-intensity sports, fitness or recreational activities on a typical** day?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins

Moderate intensity activities during recreational time

M	Do you do any moderate-intensity sports, fitness or recreational (leisure) activities that cause a small increase in breathing or heart rate such as brisk walking, swimming, volleyball for at least 10 minutes continuously?	Yes No	1 2 *If No, go to P*
N	In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (leisure) activities?	Number of days	⌊__⌋
O	How much time do you spend doing **moderate-intensity sports, fitness or recreational (leisure) activities on a typical day**?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins

Sedentary behavior

The following questions are about **sitting or reclining** at work, at home, getting to and from places, or with friends including time spent [sitting at a desk, sitting with friends, travelling in car, bus, train, reading, playing cards or watching television], but **do not include time spent sleeping**.

P	How much time do you usually spend **sitting or reclining on a TYPICAL WEEK DAY**?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins
Q	How much time do you usually spend **sitting or reclining on a TYPICAL WEEKEND DAY**?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins

Q2. Think about a TYPICAL WEEK. Write down how long you spend SITTING/RECLINING doing the followings in **a single day**.
[*please leave it BLANK if you're NOT DOING any particular task*]

Sitting or reclining during…	Total time during a typical week day (e.g., Monday)		Total time during a typical weekend day (e.g., Friday)	
	Hours	Minutes	Hours	Minutes
a. … watching TV, movie, DVD				
c. … using smartphone, tablet, notebook for fun				
d. … using computer for fun (e.g., games, browsing)				
h. … listening to music				
m. … traveling by car/bus/train				
o. … sitting talking (chatting/chilling)				
p. … talking on the phone				
t. … other (please specify) _____				
u. … other (please specify) _____				
v. … other (please specify) _____				

Q3. In a TYPICAL WEEK, how much time you spend walking?
(*please add all walking times during recreation, exercise or to get to or from places, even if they are less than 10 minutes*)

On a week day (e.g., Tuesday)	
Hours	Minutes

On a weekend day (e.g., Friday)	
Hours	Minutes

Q4. There may be some environmental factors for which people might find it difficult to do physical activity regularly. To what extent do you agree/disagree with the following statements?
[*please circle the MOST APPROPRIATE response for EACH statement*]

	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
a. The weather is often too bad to do physical activity	1	2	3	4	5
b. There are no convenient places (e.g., parks or playground) nearby for physical activity	1	2	3	4	5
c. It is not safe to walk in my neighborhood	1	2	3	4	5
d. My neighborhood is not clean and tidy	1	2	3	4	5
e. The footpaths are not in good condition in my neighborhood	1	2	3	4	5
f. There is heavy traffic in my neighborhood	1	2	3	4	5
g. Streets are not well lit during night in my neighborhood	1	2	3	4	5

Q5. There may be some reasons that make physically activity attractive to many people do regular physical activity. To what extent do you agree/disagree with the following statements?
[*please circle the MOST APPROPRIATE ONE response for EACH statement*]

If I participate in regular physical activity or sports, then I will …	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
a. … improve my physical fitness	1	2	3	4	5
b. … improve my appearance	1	2	3	4	5
c. …. improve my health	1	2	3	4	5
d. …. reduce my risk of poor health	1	2	3	4	5
e. …. help manage my weight	1	2	3	4	5

Q6. The following questions are about how other people may influence your physical activity or exercise.

During the PAST 3 MONTHS, how often have your friends, family or members of your household …	Never	Rarely	A few times	Often	Very Often	Not Applicable
a. … done physical activity with you?	0	1	2	3	4	9
b. … offered to do physical activity with you?	0	1	2	3	4	9
c. … given you helpful reminders to do physical activity? (e.g., are you going for a walk today?)	0	1	2	3	4	9
d. … given you encouragement to stick with your physical activity program?	0	1	2	3	4	9
e. … changed their schedule so you could do physical activity together?	0	1	2	3	4	9
f. … discussed physical activity with you?	0	1	2	3	4	9
g. … complained about the time you spend doing physical activity?	0	1	2	3	4	9
h. … helped plan activities around your schedule to do physical activity?	0	1	2	3	4	9
i. … asked you for ideas on how they can get more physically active?	0	1	2	3	4	9
j. … talked about how much they like to do physical activity?	0	1	2	3	4	9

Q7. Do you currently participate in <u>any organized</u> physical activity or sports (e.g., football, cricket, yoga, martial arts) on a regular basis?

Yes, at university □[1]
Yes, outside university □[2]
No □[3]

Q7a. If YES, how long do you do this in a TYPICAL WEEK?
_____ hours _____minutes/week

Q8. How often do you do the following activities?
[*please circle the MOST APPROPRIATE ONE for EACH activity*]

	Activity	None	Once a week	2-3 times weekly	Daily
a.	Cricket	0	1	2	3
b.	Football	0	1	2	3
c.	Basketball	0	1	2	3
d.	Bicycling	0	1	2	3
e.	Jogging/ running	0	1	2	3
f.	Badminton	0	1	2	3
g.	Table tennis	0	1	2	3
h.	Gym	0	1	2	3
i.	Swimming, water exercise	0	1	2	3
j.	Yoga, meditation, deep breathing	0	1	2	3
k.	Stationary exercise machines (e.g., cycle, stair climber, treadmill)	0	1	2	3
l.	Dancing (e.g., ballet)	0	1	2	3
m.	Karate/ judo/ martial arts	0	1	2	3
n.	Aerobic classes (e.g., jumping jacks, sit-ups)	0	1	2	3
o.	Bowling	0	1	2	3
p.	Hockey	0	1	2	3
q.	Tennis	0	1	2	3
r.	Volleyball	0	1	2	3
s.	Other (please write) _____	0	1	2	3
t.	Other (please write) _____	0	1	2	3

Q9. How important is physical activity in your life? [*Please tick the most appropriate one*]

Not at all important	Somewhat unimportant	Neutral	Somewhat important	Important	Very important
0	1	2	3	4	5

Q10. How certain are you that you could overcome the following barriers?
[*please circle the MOST APPROPRIATE ONE for EACH statement*]

I can manage to carry out my physical activity intentions, even when I ...	Very uncertain	Rather uncertain	Rather certain	Very certain
1. ... have worries and problems	1	2	3	4
2. … feel depressed	1	2	3	4
3. … feel tense	1	2	3	4
4. … am tired	1	2	3	4
5. … I am busy	1	2	3	4

Q11. In a TYPICAL WEEK, how much time you spend doing the following activities?
[*please leave it blank if you're not doing any particular task*]

	Activity	Hours/wk	Minutes/wk
a.	Shopping (e.g., grocery, clothes)		
b.	Stair climbing		
c.	Cleaning the house (e.g., kitchen/bathroom/bedroom)		
d.	House maintenance, outdoor cleaning		
e.	Washing clothes, hanging outside		
e.	Ironing clothes		
f.	Food preparation (e.g., chopping, stirring) and serving (e.g., setting table, carrying food)		
g.	Dish washing (e.g., clearing the table, washing dishes, putting dishes away)		
h.	Childcare (e.g., taking care of own child, babysitting for family members)		
i.	Look after parents, parent-in-laws		
j.	Other (specify)……		

Q12. In the PAST 12 MONTHS, has a doctor or healthcare professional advised you to do regular exercise/physical activity?

Yes ☐[1] No ☐[2] I can't recall now ☐[3]

Q13. In the PAST 12 MONTHS, how often has your health restricted you from doing regular physical activity?

None of the time ☐[1] A little of the time ☐[2] Some of the time ☐[3]
Most of the time ☐[4] All of the time ☐[5] I can't recall ☐[6]

This section is about **your health**

Q14. In general, how would you rate your health?

Excellent	Very good	Good	Fair	Poor
5	4	3	2	1

Q15. On a TYPICAL WEEK, how much time do you spend sleeping (including at night, naps or any other time)?

On a week day (e.g., Tuesday)	
Hours	Minutes

On a weekend day (e.g., Friday)	
Hours	Minutes

Q16. During the PAST MONTH, how often did you experience the following?
[*please circle the MOST APPROPRIATE response for EACH item*]

	Not at all	Rarely	Sometimes	Often	Almost always
a. Stress	0	1	2	3	4
b. Depression	0	1	2	3	4
c. Anxiety	0	1	2	3	4
d. Muscular pain	0	1	2	3	4
e. Headaches	0	1	2	3	4
f. Trouble concentrating	0	1	2	3	4
g. Sleep difficulties	0	1	2	3	4
h. Muscular tension	0	1	2	3	4
i. Nausea	0	1	2	3	4
j. Stomach cramps	0	1	2	3	4
o. Other (please specify) _____	0	1	2	3	4
p. Other (please specify) _____	0	1	2	3	4

Q17. During the PAST 4 WEEKS, how much of the time did you feel?
[*please circle the MOST APPROPRIATE response for EACH statement*]

	None of the time	A little of the time	Some of the time	Most of the time	All of the time
a. … so sad nothing could cheer you up	0	1	2	3	4
b. … nervous	0	1	2	3	4
c. … restless or fidgety	0	1	2	3	4
d. … hopeless	0	1	2	3	4
e. … that everything was an effort	0	1	2	3	4
f. … worthless	0	1	2	3	4

Q18. How satisfied are you with your life overall?
[*please circle the MOST APPROPRIATE ONE only*]

Not at all satisfied				Neither satisfied nor dissatisfied					Highly satisfied
1	2	3	4	5	6	7	8	9	10

Q19. How would you describe yourself in relation to cigarette smoking?
[*Please tick ONE only*]

a.	Non-smoker □[1]
b.	Past smoker □[2]
c.	Occasional smoker □[3]
d.	Regular smoker □[4]

Q19a. If you are a current smoker (regular or occasional), how many cigarette(s) do you USUALLY smoke per day or week?

_____ cigarette(s)/day OR _____ cigarette(s)/week

Q20. Which ONE of the following best describes you in relation to alcohol (e.g., local wine, beer, spirit) consumption?

a.	I never drink alcohol □[1]
b.	I don't drink now, but I used to □[2]
c.	I drink occasionally □[3]
d.	I drink regularly □[4]

This section is about **your diet**

Q21. During the PAST 7 DAYS, how often did you have the following?
[*please tick AS MANY AS appropriate and write down the number of servings, 0 if none*]

a.	Fast food (e.g. burger, pizza, hot-dog)	____ /wk
b.	Fried-food (e.g. chicken fry, samosa, french-fry)	____ /wk
c.	Chinese/Thai food (e.g. soup, fried rice)	____ /wk
d.	Chocolate/lolly/candy	____ /wk
e.	Ice-cream	____ /wk
f.	Bakery food (e.g. cream roll, cake, doughnut)	____ /wk
f.	Fresh fruit (*DO NOT count fruit juice*)	____ /wk
h.	Vegetables/green salad	____ /wk

Q22. During the PAST 7 DAYS, how many glasses/cans/bottles of soft-drinks (e.g., Coke, Pepsi) did you have?
[*please exclude diet Coke or diet cola type soft drinks*]

None ☐0 1-2 glasses ☐1 3-4 ☐2 5-6 ☐3 7-9 ☐4 10-13 glasses ☐5 14+ glasses ☐6

Q23. During the PAST 7 DAYS, on how many days did you eat breakfast?

None ☐0 1 ☐1 2 ☐2 3 ☐3 4 ☐4 5 ☐5 6 ☐6 Everyday ☐7

Q24. During the PAST SEVEN DAYS, how many days did you bring home made lunch at the university?

None ☐0 1 ☐1 2 ☐2 3 ☐3 4 ☐4 5 ☐5 6 ☐6

This section is all about yourself, you family and your education

Q25. Which program are you in?

a) Science ☐1
b) Biological Science ☐2
c) Humanities ☐3
d) Engineering ☐4
e) Business ☐5
f) Other (please specify) ☐5 _____

Q26. Which year of study are you in?

a) Year 1 ☐1
b) Year 2 ☐2
c) Year 3 ☐3
d) Year 4 ☐4

Q27. During your time in high school where did you live most of the time?

a) a divisional town ☐1
b) a district town ☐2
c) an upuzilla town ☐3
d) a village ☐4
e) Other (please specify) ☐5 _____

Q28. How do you USUALLY come to the university and MOST OF THE TIME and how long does it take (one way) on a typical day? (please select AS MANY AS APPLICABLE)

Mode of transport	Time required	
	Hours	Minutes
1. Walk		
2. Bicycle		
3. Rickshaw		
4. CNG		
5. Car		
6. Bus		
7. Other		

Q29. How old are you? _____years

Q30. Are you: Male ☐1 Female ☐2

Q31. Are you:

a) Single ☐1
b) Married ☐2
c) Divorced ☐3
d) Widowed ☐4
e) Separated ☐5
f) Other (please write) ☐6 _____

Q32. Do you have any children? Yes □[1] No □[2]

Q33. Your height (without shoes) _____ feet _____ inches OR _____ cm

Q34. Your weight _____ kgs OR _____ lbs

Q35. Which of the following best describe your parents' highest level of education?
[*please tick the most appropriate ONE*]

Mother	Father
a. No formal education □[1]	a. No formal education □[1]
b. Primary or equivalent □[2]	b. Primary or equivalent □[2]
c. Secondary (SSC) or equivalent □[3]	c. Secondary (SSC) or equivalent □[3]
d. Higher secondary (HSC) or equivalent □[4]	d. Higher secondary (HSC) or equivalent □[4]
e. Tertiary (university) or equivalent □[5]	e. Tertiary (university) or equivalent □[5]

Q36. Which of the following best describe your parents' current occupation?
[*please tick the most appropriate ONE that represents the MAIN one*]

Mother	Father
a. Government (public) service □[1]	Government (public) service □[1]
b. Non-government (private) service □[2]	Non-government (private) service □[2]
c. Professional (e.g., doctor, lawyer, teacher) □[3]	Professional (e.g., doctor, engineer) □[3]
d. Self-employed/business □[4]	Self-employed/business □[4]
e. Semiskilled labor (e.g., garments worker) □[5]	Semiskilled labor (e.g., garments worker)□[5]
f. Unskilled labor (e.g., day laborer) □[6]	Unskilled labor (e.g., day laborer) □[6]
g. Farmer/agricultural worker □[7]	Farmer/agricultural worker □[7]
h. Home based manufacturing □[8]	Home based manufacturing □[8]
i. Housewife □[9]	Other (please specify) □[9]_____
j. Other (please specify) □[10] _____	

Q37. Which of the following best describes your TOTAL MONTHLY family income?
[*please tick the most appropriate ONE*]

a. ≤ 10,000 tk □[1]	b. 10,001-20,000 tk □[2]
c. 20,001-30,000 tk □[3]	d. 30,001-40,000 tk □[4]
e. 40,001-50,000 tk □[5]	f. 50,001-70,000tk □[6]
g. 70,001- 1 lac tk □[7]	h. 1- 1.5 lac tk □[8]
i. 1.5 – 2 lac tk □[9]	j. More than 2 lac tk □[10]

Q38. Where do you live?

a) Own house/flat □[1]
b) Rented house/flat □[2]
c) University accommodation/hall □[3]
d) Shared house/student mess □[4]
e) Other □[5] (please specify) _____

Q39. What is your living arrangement?

a. Living alone □[1]
b. Living with parents □[2]
c. Living with husband/wife □[3]
d. Living with other family members (e.g., uncles' or elder brother's house) □[4]
e. Living with friends/colleagues □[5]
f. Living with others (please specify) □[6] _____

Q40. Do you use the following in your bedroom? (*please tick AS MANY AS APPROPRIATE)*

TV □[1] Computer □[2] Laptop □[3] Other small screen (e.g., Tablet) □[4]

Q41. Do you have any private vehicle (e.g. car, motorcycle) that you have frequent access to?
Yes, always □[1] Yes, sometimes □[2] Yes, but occasionally □[3] No □[4]

Q42. Who MAINLY supports your study financially?

Parents □[1] Relatives □[2] Self through my job □[3] Family+self □[4] Study loan □[5]
Other (please specify) □[6] _____

Q43. Do you do any paid (part-time or full-time) job? Yes □[1] No □[2]

Q44a. If yes, how long do you work per week? _____ hours/week

Q44. What are the ways you think might help university students to be more active?

.....
.....
.....
.....
.....
.....
.....

If you have anything else you would like to share, please write on the lines below

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

……

……

Thank you very much for your help

Thanks in advance for participating in the FOLLOW-UP survey in 2016

I look forward to seeing you in a year

Appendix C: Wave 2 survey materials

C1: Wave 2 participant information sheet

Physical activity of university students of Dhaka, Bangladesh

Participants' Information Sheet

You have participated in this study last year and we are inviting you to complete a follow-up survey today. We are asking you to take part in this survey as you indicated your willingness to complete a follow-up survey in 2016 when you completed the baseline survey in 2015. The follow-up survey is a sub-set of the main survey used in 2015, so it should not take more than 30 minutes, which you would complete at your classroom. The follow-up survey contains a series of questions about your physical and psychological health, physical activity, sedentary behaviour, dietary habit, as well as few physical attributes such as your height and weight.

What is the study about?

Young adults go through a transitional period of their life from adolescence to adulthood, which is a critical phase of life. Different risky health behaviours adapted during the early adulthood is supposedly set the base for increased risk of developing a number of chronic conditions in later life, like obesity, hyperlipidaemia, and diabetes. As little is known about health and wellbeing of young adults in Bangladesh, the present study aims to examine different aspects of health, wellbeing, physical activity, sedentary behaviour, and dietary behaviour of young adults (aged 18-24 years) in Dhaka city. The information you provided at baseline has helped us to understand physical activity and sedentary behaviour of your age group. However, to understand how you went over the past year, and what have changed since you participated at the baseline, we would like to invite you to complete this follow-up survey. Your participation in the follow-up survey will help us to understand changes, if any, in different behaviours over time, and as such, we will be able to draw a comprehensive picture of physical activity and sedentary behaviour of university students in in Dhaka city.

Why am I doing this survey again?

We thank you for your participation at the baseline; your contribution is valuable beyond estimation. This follow-up survey will help us detecting developments or changes in your above mentioned behaviours both at the group and the individual level.

So this is the same survey?

This survey is a subset of the baseline survey. It does not include demographic information age, education, and living condition. This survey excludes most of the attitudinal items as well. It can be completed at your classroom, same as baseline survey, which is expected to take around 25-30 minutes.

Are there any risks or benefits?

We do not anticipate any risk associated with participating in this study. The obtained information will help us to develop a better understanding of different key aspects of health and wellbeing of young adults of Dhaka city and how they change (if any) over one year. When you respond to the follow-up survey, you are doing your part to help the researchers understanding a comprehensive scenario in this regard. Filling out the follow-up survey offers you an opportunity to reflect on your own individual experiences over past year. Your contribution will help us informing policy makers to promote different avenues for healthy lifestyle. As such, participation in this follow-up survey is a good opportunity for you to shape the health of young adults in the future. Subsequent generations of students will be benefited from your contribution. This in turn will be useful to develop strategies to promote healthy lifestyles and wellbeing of young adults of Bangladesh.

Your participation and privacy

Participation in this follow-up study is completely voluntary. If you do not wish to be part of the study, you can withdraw at any stage. All information you provide will be anonymous, confidential and kept in locked storage. Your name will not be used in any written or published document or recorded on the survey. We will not identify individuals in any reports, and only summary results will be reported. Only the project team will have access to the data.

Investigators

Mr Riaz Uddin, PhD Student, School of Health & Rehabilitation Sciences, The University of Queensland, Australia
Dr Nicola Burton, Senior Research Fellow, School of Movement and Nutrition Sciences, The University of Queensland, Australia
Dr Asad Khan, Senior Lecturer, School of Health & Rehabilitation Sciences, The University of Queensland, Australia

Questions?

If you have any questions regarding this project you can contact Mr Riaz Uddin on mobile 01680106009 or by email: riaz.uddin@uq.net.au. This study adheres to the Guidelines of the ethical review process of The University of Queensland. Whilst you are free to discuss your participation in this study with project staff, if you would like to speak to an officer of the University not involved in the study, you may contact the Ethics Officer on +61 7 3365 3924 or by email: humanethics@research.uq.edu.au

Many thanks for your participation in this important survey

☺

C2: Wave 2 questionnaire

Physical Activity of University Students of Dhaka, Bangladesh

Before we begin, please write your own identification code as you did during the baseline survey. This unique code is **identifiable only to you**. The code will allow the researchers to match this survey with the baseline survey while **protecting your anonymity**.

Please follow the instructions bellow:

i) Write the **FIRST 3 LETTERS** of father's last/family name (e.g., Mostafa = MOS)
ii) Write the **FIRST 3 LETTERS** of mother's last/family name (e.g., Begum = BEG)
iii) Write the **DATE OF YOUR BIRTH** (if you were born on the 19th, write 19)
iv) Write **NUMERICALLY** your **MONTH OF BIRTH** (if you were born in February, write 02)

This *example code* would look like this:

M	O	S	-	B	E	G	-	1	9	-	0	2

Now please write **your own code** here:

			-				-			-		

Physical activity means movement of the body and includes things like exercise, sports, swimming, walking, cycling.

Sedentary activities include works, which cause LITTLE or NO movement (e.g., sitting at a desk, travelling in car, bus, reading, working on a computer, watching television)




Moderate-intensity activities require moderate physical effort and causes SMALL INCREASES in breathing or heart rate (e.g., playing cricket, golf, slow swimming)




Vigorous-intensity activities require hard physical effort and cause LARGE INCREASES in breathing or heart rate (e.g., athletics, competitive sports- playing football, basketball)



WHO Global Physical Activity Questionnaire (GPAQ)

Q1. The following questions ask you about the time you spend doing different types of physical activity in a **TYPICAL WEEK**. Please answer these questions even if you do not consider yourself to be a physically active person.

Think first about the time you spend doing work. Think of work as the things that you have to do such as paid or unpaid work, **STUDY/TRAINING**, household chores, harvesting food/crops, seeking employment.

In answering the following questions ***'vigorous-intensity activities'*** are activities that require hard physical effort and cause large increases in breathing or heart rate, '***moderate-intensity activities***' are activities that require moderate physical effort and cause small increases in breathing or heart rate.

	Questions	Response	
Activity at work/study			
Vigorous intensity activities at work/study			
A	Does your work **(including STUDY/TRAINING)** involve vigorous-intensity activity that causes large increases in breathing or heart rate like carrying or lifting heavy loads, digging or construction work for at least 10 minutes continuously?	Yes No	1 2 *If No, go to D*
B	In a typical week, on how many days do you do vigorous-intensity activities as part of your work?	Number of days	⌊__⌋
C	How much time do you spend doing vigorous-intensity activities **at work on a typical day**?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins
Moderate intensity activities at work/study			
D	Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as **walking to attend classes** or carrying light loads for at least 10 minutes continuously?	Yes No	1 2 *If No, go to G*
E	In a typical week, on how many days do you do moderate-intensity activities as part of your work?	Number of days	⌊__⌋
F	How much time do you spend doing moderate-intensity activities **at work on a typical day**?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins
Travel to and from places			
The next questions **exclude the physical activities at work/study that you have already mentioned**. Now I would like to ask you about the usual way you travel to and from places. For example to work, for shopping, to market, to place of worship.			
G	Do you walk or use a bicycle for at least 10 minutes continuously to get to and from places?	Yes No	1 2 *If No, go to J*
H	In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?	Number of days	⌊__⌋
I	How much time do you spend **walking or bicycling for travel on a typical day**?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins

Recreational activities

The next questions **exclude the work/study and transport activities** that you have already mentioned.

Now I would like to ask you about sports, fitness and recreational activities (leisure time activities).

Vigorous intensity activities during recreational time

J	Do you do any vigorous-intensity sports, fitness or recreational (leisure) activities that cause large increases in breathing or heart rate like (running or playing football) for at least 10 minutes continuously?	Yes	1	
		No	2	*If No, go to M*
K	In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (*leisure*) activities?	Number of days	⌊__⌋	
L	How much time do you spend doing **vigorous-intensity sports, fitness or recreational activities on a typical** day?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins	

Moderate intensity activities during recreational time

M	Do you do any moderate-intensity sports, fitness or recreational (leisure) activities that cause a small increase in breathing or heart rate such as brisk walking, swimming, volleyball for at least 10 minutes continuously?	Yes	1	
		No	2	*If No, go to P*
N	In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (leisure) activities?	Number of days	⌊__⌋	
O	How much time do you spend doing **moderate-intensity sports, fitness or recreational (leisure) activities on a typical day**?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins	

Sedentary behavior

The following questions are about **sitting or reclining** at work, at home, getting to and from places, or with friends including time spent [sitting at a desk, sitting with friends, travelling in car, bus, train, reading, playing cards or watching television], but **do not include time spent sleeping**.

P	How much time do you usually spend **sitting or reclining on a TYPICAL WEEK DAY**?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins
Q	How much time do you usually spend **sitting or reclining on a TYPICAL WEEKEND DAY**?	Hours : minutes	⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins

Q2. Think about a TYPICAL WEEK. Write down how long you spend SITTING/RECLINING doing the followings in **a single day.**

[*please leave it BLANK if you're NOT DOING any particular task*]

Sitting or reclining during…	Total time during a typical week day (e.g., Monday)		Total time during a typical weekend day (e.g., Friday)	
	Hours	Minutes	Hours	Minutes
a. … watching TV, movie, DVD				
c. … using smartphone, tablet, notebook for fun				
d. … using computer for fun (e.g., games, browsing)				
h. … listening to music				
m. … traveling by car/bus/train				
o. … sitting talking (chatting/chilling)				
p. … talking on the phone				
t. … other (please specify) _____				
u. … other (please specify) _____				
v. … other (please specify) _____				

Q3. Do you use the following in your bedroom? (*please tick AS MANY AS APPROPRIATE)*

TV ☐1

Computer ☐2

Laptop ☐3

Other small screen (e.g., Tablet) ☐4

Q4. Do you currently participate in any organized physical activity or sports (e.g., football, cricket, yoga, martial arts) on a regular basis?

Yes, at university ☐1
Yes, outside university ☐2
No ☐3

Q4a. If YES, how long do you do this in a TYPICAL WEEK?
_____ hours _____minutes/week

Q5. How often do you do the following activities?
[*please circle the MOST APPROPRIATE ONE for EACH activity*]

	Activity	None	Once a week	2-3 times weekly	Daily
a.	Cricket	0	1	2	3
b.	Football	0	1	2	3
c.	Basketball	0	1	2	3
d.	Bicycling	0	1	2	3
e.	Jogging/ running	0	1	2	3
f.	Badminton	0	1	2	3
g.	Table tennis	0	1	2	3
h.	Gym	0	1	2	3
i.	Swimming, water exercise	0	1	2	3
j.	Yoga, meditation, deep breathing	0	1	2	3
k.	Stationary exercise machines (e.g., cycle, stair climber, treadmill)	0	1	2	3
l.	Dancing (e.g., ballet)	0	1	2	3
m.	Karate/ judo/ martial arts	0	1	2	3
n.	Aerobic classes (e.g., jumping jacks, sit-ups)	0	1	2	3
o.	Bowling	0	1	2	3
p.	Hockey	0	1	2	3
q.	Tennis	0	1	2	3
r.	Volleyball	0	1	2	3
s.	Other (please write) _____	0	1	2	3
t.	Other (please write) _____	0	1	2	3

Q6. In a TYPICAL WEEK, how much time you spend walking?
(*please add all walking times during recreation, exercise or to get to or from places, even if they are less than 10 minutes*)

On a week day (e.g., Tuesday)	
Hours	Minutes

On a weekend day (e.g., Friday)	
Hours	Minutes

Q7. How do you USUALLY come to the university and MOST OF THE TIME and how long does it take (one way) on a typical day? (please select AS MANY AS APPLICABLE)

Mode of transport		Time required	
		Hours	Minutes
1.	Walk		
2.	Bicycle		
3.	Rickshaw		
4.	CNG		
5.	Car		
6.	Bus		
7.	Other		

Q8. How important is physical activity in your life? [*Please tick the most appropriate one*]

Not at all important	Somewhat unimportant	Neutral	Somewhat important	Important	Very important
0	1	2	3	4	5

Q9. How certain are you that you could overcome the following barriers?
[*please circle the MOST APPROPRIATE ONE for EACH statement*]

	I can manage to carry out my physical activity intentions, even when I ...	Very uncertain	Rather uncertain	Rather certain	Very certain
1.	... have worries and problems	1	2	3	4
2.	… feel depressed	1	2	3	4
3.	… feel tense	1	2	3	4
4.	… am tired	1	2	3	4
5.	… I am busy	1	2	3	4

Q10. During the PAST MONTH, how often did you experience the following?
[*please circle the MOST APPROPRIATE response for EACH item*]

	Not at all	Rarely	Sometimes	Often	Almost always
a. Stress	0	1	2	3	4
b. Depression	0	1	2	3	4
c. Anxiety	0	1	2	3	4
d. Muscular pain	0	1	2	3	4
e. Headaches	0	1	2	3	4
f. Trouble concentrating	0	1	2	3	4
g. Sleep difficulties	0	1	2	3	4
h. Muscular tension	0	1	2	3	4
i. Nausea	0	1	2	3	4
j. Stomach cramps	0	1	2	3	4
o. Other (please specify) ……..	0	1	2	3	4
p. Other (please specify) ……..	0	1	2	3	4

Q11. During the PAST 4 WEEKS, how much of the time did you feel?
[*please circle the MOST APPROPRIATE response for EACH statement*]

	None of the time	A little of the time	Some of the time	Most of the time	All of the time
a. … so sad nothing could cheer you up	0	1	2	3	4
b. … nervous	0	1	2	3	4
c. … restless or fidgety	0	1	2	3	4
d. … hopeless	0	1	2	3	4
e. … that everything was an effort	0	1	2	3	4
f. … worthless	0	1	2	3	4

Q12. In the PAST 12 MONTHS, how often has your health restricted you from doing regular physical activity?

None of the time □[1] A little of the time □[2] Some of the time □[3]

Most of the time □[4] All of the time □[5] I can't recall □[6]

Q13. How satisfied are you with your life overall?
[*please circle the MOST APPROPRIATE ONE only*]

Not at all satisfied				Neither satisfied nor dissatisfied					Highly satisfied
1	2	3	4	5	6	7	8	9	10

Q14. Your height (without shoes) _____feet_____inches OR _____cm

Q15. Your weight _____kgs OR _____lbs

Q16. What are the ways you think might help university students to be more active?

.....

.....

.....

.....

.....

.....

.....

.....

If you have anything else you would like to share, please write on the lines below

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Thank you for participating in the FOLLOW-UP survey