Interactions Among Biopsychosocial Predictors of Somatic Pain in Australian Adolescents: A Nationally Representative Survey

by

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Abstract

The prevalence of somatic pain (headache, stomach ache, backache) in late adolescence is similar to adulthood, positioning adolescent pain as a significant public health issue. Pain in adolescents is complex and multi-factorial in nature however, the predictors of somatic pain are not well understood. We conducted a secondary analysis of data collected via an online survey from The Australian Child Wellbeing Project (ACWP). Participants were Australian school children aged 8 - 14 years. Somatic pain items were measured using the Health Behaviour in School-Aged Children's – Symptoms Checklist (HBSC-SCL). A somatic pain summary score was the aggregated headache, stomach ache and backache items (range 0 to 15). Identification of the strongest predictors, moderation and direct and indirect paths were constructed to investigate the relationship between 16 different physical, psychological and social predictors and somatic pains stratified by gender. The sample was 4,572 adolescents (52% Girls). The average frequency score of somatic pain for adolescents was 6.0±2.9 (range 0 to 15). Emotional state was identified as the most significant predictor associated with all somatic pain types, which is similar between both boys and girls. The current study also identified predictors relating to relationships with peers and school environment being moderately associated with somatic pains. We also identified that psychosocial factors such as bullying, support of friends and school satisfaction moderate the relationship between negative emotional state and somatic pains. Psychosocial factors largely operate through indirect pathways via emotional state in their association with somatic pain types. Conversely physical factors such as puberty were not associated with any somatic pain type. Overall somatic pain places a large burden on Australian boys and girls across Australia and appears to be predominantly associated with psychological and social predictors.

Presentations:

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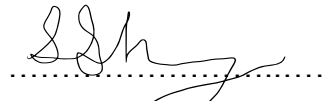
Declaration of Originality

The works found within this thesis are original and have not been submitted for publication, written by another person, nor submitted for a higher degree to any other university or institution. The empirical research contained within this thesis was approved by the Human Research Ethics Committee at Macquarie University (reference number: 5201600085)



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Chapter One: Introduction

1.1 An Overview

Adolescence is a pivotal phase of life and is defined as the period in human growth and development that occurs after childhood and before adulthood from the ages of 10 to 19 years (WHO, 2016). It represents one of the critical transition period along the life course, which is characterised by a rapid change in growth and development that is second only to that of infancy (WHO, 2016). Adolescent development not only includes biological maturation, but psychological and social developments, which occur simultaneously during this phase of life. The behaviours, habits and patterns developed in this phase of life flow onto adulthood and are therefore pivotal to the future health behaviours of the individual. Adolescents represent 27% of the world's population (Gore et al., 2011) and it is thought that many of the conditions causing poor health in adulthood could have their roots in health related decisions and changes which commenced in adolescence (Heaven, 1996; Viner et al., 2012). To understand adolescence, it is important to look at the numerous biological, psychological and social factors, which are frequently associated with health status.

Pain is a large contributor to poor health status across the life course and is defined as an unpleasant emotional and sensory experience often associated with actual or potential tissue damage (Taxonomy, 2014). Somatic pain is a sub-type of nociceptive pain, where signals from (i.e. pain related to) skin, muscle, bone or gut tissues without organic disease are being perceived as painful within the brain (Kröner-Herwig, Gassmann, Van Gessel, & Vath, 2011). Headache, stomach-ache and backache are the most common forms of somatic pains in adolescents (Calvo-Munoz, Gomez-Conesa, & Sanchez-Meca, 2013; Swain et al., 2014).

A recent international survey of over 400,000 adolescents from 28 countries found that 54% experienced headache, 50% experienced stomach-ache and 37% experienced backache at least monthly (Swain et al., 2014). In this study girls were more likely to experience somatic pain than boys and somatic pains became significantly more common between the ages of 11 to 15 years. The large majority of research to date has focused on individual locations (types) of pain, which tend to be the result of the focus of individual disciplines; for example, a neurologist studies headache, a gastroenterologist studies abdominal pain and a physiotherapist or chiropractor studies back pain (Von Baeyer & Champion, 2011). However, recent epidemiological studies have suggested that the majority of adolescents who experience one somatic pain also experience multiple somatic pains in more than one location over time (King et al., 2011; Kröner-Herwig et al., 2011; Swain et al., 2014). Therefore, models or frameworks which encapsulate the whole pain experience by looking at multiple systems are important in order to properly understand the somatic pain experience in adolescents.

The biopsychosocial model described by (Engel, 1980) provides a theoretical framework for examining the complex interactions of biological, psychological and social factors in the context of somatic pains. The period of adolescence is a time of rapid physical, psychological and social change which has been associated with a number of somatic pain types (LeResche, Mancl, Drangsholt, Saunders, & Von Korff, 2005). We know that a number of psychosocial factors such as somatisation, anxiety and life stressors have an influence on somatic conditions in the adult population (van Tilburg, Spence, Whitehead, Bangdiwala, & Goldston, 2011). However, we currently do not know enough about these associations in adolescence. Presumably the complex interactions expressed in the biopsychosocial model are developed during adolescence, with the established relationships between emotional state and somatic pain lasting through to adulthood. The current thesis is therefore, focused on

identifying predictors of adolescent somatic pain, as well as factors which moderate those predictors. This introduction will review the literature on the prevalence of somatic pain and investigate the association between biological, psychological and social predictors and somatic pain.

1.2 Frequency and Prevalence of Somatic Pain

Somatic pain is very common and there are concerns that rates are rising over time (Freburger et al., 2009; McBeth & Jones, 2007). Almost three quarters of adolescents experience headache, stomachache or backache at least monthly (Swain et al., 2014), with the prevalence rates of these types of pain increasing as the adolescent age increases. Data on the epidemiology of these conditions varies across the globe, but, overall taken together, show the high incidence, and overlap, of these symptoms.

The most common somatic pain in adolescents is headache with the monthly prevalence ranging from 26% to 69% reported in systematic literature reviews (Jeffries, Milanese, & Grimmer-Somers, 2007; King et al., 2011). A study in 2005 found that 26% of children aged 12-13 years reported headaches at least once per week, compared with 31% of those aged 14-15 years (Dooley, Gordon, & Wood, 2005). The reported incidence of recurrent abdominal pain in adolescence ranges from 8% to 19% in Western countries (Chitkara, Rawat, & Talley, 2005), and globally, the estimated monthly prevalence of abdominal pain is 49.8% (Swain et al., 2014). Back pain is also common in adolescence with the reported 1-year incidence of low back pain in adolescent's ranging from 11.8% to 33%, and the 1-month prevalence ranges from 9.8% to 36% (Jeffries et al., 2007; Swain et al., 2014). The 1-month prevalence of low back pain doubles between children in England aged 11 years (16%) and 14 years (34%) (Watson et al., 2002). A large majority of adolescents experience multiple pains with the monthly prevalence of multiple pains (pain in more than

one location) in children and adolescents ranging from 12.1% to 35.7% (King et al., 2011; Swain et al., 2014). Therefore, models which encapsulate the whole pain experience are important as they allow a broader understanding of the adolescent population and potential predictors of pain.

1.3 Inequality Between Genders

In children and adolescents, it is well understood that girls experience more pain than boys, both in terms of a greater number of multiple pains, and an increased rate of multiple pains as they age (King et al., 2011; Swain et al., 2014). Several studies have found that girls are more likely to experience headaches (Bandell-Hoekstra et al., 2001; Barea, Tannhauser, & Rotta, 1996; King et al., 2011; Sundblad, Saartok, & Engström, 2007). There are many theories in regards to etiology including changes in psychosocial and biological structure however these associations have not been fully explained due to a lack of available data (King et al., 2011). There is a similar trend with recurrent abdominal pain with a recent review reporting that girls have a weekly prevalence of 27% compared to 18% in boys (King et al., 2011). Lower back pain does not differ between genders according to a systematic literature review (King et al., 2011). One study showed the difference between genders experiencing a 1-month prevalence between ages 11-14years was 29% in girls and 19% in boys (Watson et al., 2002). A more recent survey found the prevalence to be 38.9% for girls and 35.0% for boys (Swain et al., 2014). In summary, girls experience more pain through adolescence and it is thought that psychosocial and biological factors may play a role in pain experiences for both genders. Globally, somatic pains are the leading cause of disability (Kamper, Henschke, Hestbaek, Dunn, & Williams, 2016; Wober-Bingol, 2013) and they pose an enormous burden to both the individual and society (Henschke, Kamper, & Maher, 2015) with increasing rates over time (Freburger et al., 2009; McBeth & Jones, 2007).

1.4 Burden

1.4.1 Economic. There is a large individual and societal economic burden associated with adolescent somatic pain conditions. It is estimated that the mean cost per adolescent experiencing chronic somatic pain in the United Kingdom is approximately £8000 per year, inclusive of direct and indirect costs (Sleed, Eccleston, Beecham, Knapp, & Jordan, 2005). Current literature suggests that adolescents who experience pain are more likely to go onto experience future pain in adulthood (Beck, 2008; Hestbaek, Leboeuf-Yde, Kyvik, & Manniche, 2006; Kamaleri, Natvig, Ihlebaek, Benth, & Bruusgaard, 2009; Reeve, 2000). There is a paucity of evidence looking at the economic burden in adolescents, however in adults there is a large economic impact of back pain alone estimated at $1 billion in 2001 in Australia (Walker, Muller, & Grant, 2003). Chronic pain has a large impact on a patient's quality of life (Sleed et al., 2005) with an estimated financial impact of $10,827 per year for an adult with chronic pain (Sleed et al., 2005). Multiple pains in adolescents have more frequently been linked to the development of chronic pain, which is either recurrent or persistent in nature interfering with daily functional activities, such as missing school (Croft, Blyth, & van der Windt, 2010; King et al., 2011), and has been associated with poor mental health at the time and a poor socioeconomic position into adulthood (Due et al., 2011).

1.5 Pain Across the Life Course

There is mounting evidence that adolescent factors have a profound influence on later adult health (Due et al., 2011). This is true for musculoskeletal pain such as back pain (Hestbaek et al., 2006; Kamaleri et al., 2009), gastrointestinal (Beck, 2008), emotional health disorders (Reeve, 2000) and socioeconomic factors (Uphoff, Pickett, Cabieses, Small, & Wright, 2013). For example, a Danish twins study found that adolescents who experienced

persistent low back pain in childhood were 3.5 times as likely to experience low back pain in adulthood (Hestbaek et al., 2006). Due to the difficulty of obtaining longitudinal data on children there is a lack of understanding of the interactions between adolescent factors of development, emotional health and social predictors and their association with somatic pain syndromes, which, the current study aimed to investigate in the Australian adolescent population.

1.6 Mood and Pain

Mood disorders are on a spectrum of severity with studies showing an association between periods of depressed mood and increased somatic pain in adolescents (Due et al., 2011; Dunn, Jordan, Mancl, Drangsholt, & Le Resche, 2011; Eccleston et al., 2014). There are suggestions that recurrent depressed mood states may be linked with boarder personality traits such as neuroticism (Barlow, Sauer-Zavala, Carl, Bullis, & Ellard, 2014). Neuroticism is defined as the tendency to experience frequent and intense negative emotions in response to various sources of stress, such as anxiety, fear, irritability, anger, and sadness (Clark & Watson, 2008). It is thought that this trait is developed through genetic, neurobiological and psychological processes (Barlow et al., 2014).

Research suggests that high-order personality factors may have influences on pain experiences (Ferguson, 2013; Wilner, Vranceanu, & Blashill, 2014). The proposed theory is that underlying personality traits such as neuroticism may develop depressed mood states due to a change in the ability to deal with painful experiences (Ferguson, 2013). It is thought that neuroticism has an impact on how people interpret and cognitively process pain and it is thought to be a malleable process (Barlow et al., 2014). The mechanism through which neuroticism is related to pain still remains relatively inconclusive with only a small number of studies. The central sensitisation theory where undue stressors activate a feed-forward

mechanism sensitising complex neuronal networks leading to pain could be a possible explanation (Brosschot, 2002). The data available are not conclusive, however this does provide a framework to understand more deeply the association with mood disorders (anxiety and depression) and their influence on the expression of pain in adolescents (Wilner et al., 2014).

1.7 Depression and Anxiety Across the Life Course

Similar to somatic pain, longitudinal studies indicate that the first episode of a mood disorders (depression and anxiety) will tend to occur before adulthood (Kim-Cohen et al., 2003). During the period of adolescence, the risk for an occurrence of a depressive episode rises from 5 to 20% (Hankin, 2008; Thapar, Collishaw, Pine, & Thapar, 2012). One of the major factors that influences this sudden change in occurrence is thought to be rapid, uncontrollable biological, psychological and social developmental changes, which predispose episodes of altered mood (Giedd et al., 1999; Paus, Keshavan, & Giedd, 2008). Studies have found that up to 35% of adolescents experience periods of depressed mood which have a large impact on the individual and society (Petersen et al., 1993).

During the adolescent phase of life there is an increase in the ratio between boys and girls affected by depressed mood states: that is more girls experience symptoms of depressed mood states in proportion to boys (Gore et al., 2011; Bo Larsson & Sund, 2007). The reason for this change is not completely understood however it is thought that hormonal changes might have an effect making environmental / social stressors more sensitive (Rocha, Prkachin, Beaumont, Hardy, & Zumbo, 2003). As highlighted earlier it is these stressors which are thought to activate feed-forward mechanisms associated with central sensitisation leading to pain (Brosschot, 2002; Ottova et al., 2012; Thayer & Brosschot, 2005). Anxiety is characterised by distress and worry that may be generalised from certain triggers (beyond

pain), such as separation from parents, certain social situations or even interactions with objects (Cunningham et al., 2013). It is well established that there is a relationship between anxiety and functional abdominal pain in adolescents, thought to be due to heightened physiological arousal levels, which could be linked with other somatic conditions such as back pain and headaches (Cunningham et al., 2013).

During the period of adolescence, neural development occurs which is important in establishing neural networks that are carried onto adulthood (Giedd, 2004; Patton & Viner, 2007). Understanding aspects of psychological development is important not only for adolescent health and pain experiences but for the prevalence and management into adulthood. It is thought that adults who suffer from bouts of depression often trace their first episode back to a time in adolescence (Costello et al., 2002). Therefore, it is important to look at psychological development as an investigation into early negative emotional states being a predictor of somatic pains in Australian adolescents.

1.8 Psychological Development

1.8.1 Neurological and Cognitive Development. Pain is a neurocognitive sensory experience modulated by the nervous system. Neurodevelopment in adolescence is a complex process that includes neural and hormonal changes occurring due to pubertal development, changes in social relationships with parents and peers as well as school environment (Giedd, 2004). At the age of 6 years the brain has reached 90% the size of an adult brain, however the complex interactions and structure are vastly different (Giedd, 2004). This stage of development is very important in the laying down the neural networks and functions which continue into adulthood (Patton & Viner, 2007).

Around this time of adolescence there are gross morphological changes in the brain including changes in the amount of white and gray matter as a result of an increase in

myelination of both cortical and subcortical tracts (Sisk & Foster, 2004). Different areas of the brain seem to develop at different rates (Giedd, 2004). One of the last areas to develop is the dorsolateral prefrontal cortex (DLPC), which continues to develop years after puberty (Giedd, 2004). This is important when talking about emotional development as the DLPC is responsible for the ability to inhibit impulses, weigh consequences of decisions, prioritise and strategise (Giedd, 2004), which is relevant to the relationships that adolescents develop with their parents and peers. Research suggests that adolescents who have secure relationships with their parents generally have better emotional adjustments and fewer behavioral problems. Conversely if the adolescent feels less connected to their parents their ability to be able to cope with challenges decreases (Sigelman C, 2006). Similarly, adolescents move towards forming peer relationships built on psychological qualities such as having similar interests, attitudes and values. These relationships are important as they become pivotal to providing support when emotional problems arise thus encapsulating psychosocial stability for the individual which is thought to be important in pain coping strategies (Sigelman C, 2006).

There are profound differences between sexes in the neurodevelopment of brain function during adolescence. Frontal lobes, which are responsible for planning, organising and executive functions, reach a peak thickness at 11 years old in girls and 12.1 years in boys (Giedd, 2004). Normal development is thought to be affected by stress as it has an effect on neurodevelopment and sets up a vulnerability to psychological mood based pathologies and somatic pain (Cameron, 2004; Due et al., 2011; King et al., 2011).

As well as neurodevelopment there are major changes in cognitive development which is the ability of acquiring knowledge to understand the process of intelligence (Taylor, 2005). It is important as it recognises the association between the biological, psychological and social

situations that have a profound influence on the neural and cognitive development of the adolescent. Throughout the 20th century there were many psychologists and theorists who proposed that cognitive development was a result of various influences placed on the individual. Piaget suggested that children of different ages think in different ways and believed that children's thinking was constrained by brain development and the tendencies rooted with their biological make up (Piaget & Cook, 1952; Sigelman C, 2006). He proposed four major cognitive developmental stages including sensorimotor stage (birth to age 2), the preoperational stage (ages 2 to 7), the concrete operations stage (ages 7 to 11) and the formal operations stage (ages 11 to 12 or older). The overarching idea of this theory is that humans will think quantitatively different as they move through the life course. During the period of adolescence Piaget suggests that thinking moves from concrete operational types to formal operational at the age of 11 or 12 years (Shaffer, 2005).

Conversely Vygotsky's theory challenges the ideals of Piagets theory that adolescence develop through universal stages of cognitive development. Vygotsky proposes that adolescents develop as a result of the social interactions with parents, teachers and other knowledgeable members of society. However, in reality it is a balance between the biological (genetic) in combination with social and cultural interactions which ultimately shape and form proper cognitive development (Shaffer, 2005). Therefore, if the adolescent grows up with the normal sensory experiences all is likely to go well in the cognitive development of the adolescent. Therefore, it is fair to suggest that the emotional and cognitive development of the adolescent is a pivotal part in laying down good habits in emotional health to extend into adult life (Sigelman C, 2006) which is important in pain perception.

1.8.2 Emotional Differences Across Genders. Similar to the gender difference of somatic pain, studies suggest that girls are generally more anxious, cautious and fearful

(Feingold, 1994) and are more prone to developing depressed mood disorders (Vriezen & Pigott, 2002). Boys are more likely to engage in risky behaviors which vary with age (Byrnes, Miller, & Schafer, 1999; Pinker & Ullman, 2002). It is thought that the broader gender inequality in society may have an overall effect on children and adolescents and how they emotionally develop which is dependent on cultural influences (Feingold, 1994). Therefore, it is important to place psychological differences within a social context that helps shape and impacts the emotional developmental process between genders.

1.8.3 Emotional Development. As adolescents develop there is an increase in depressed mood states where the individuals may begin to experience negative emotions (Hankin, 2008). This is often as a result of changes in sexual maturity and different situations or events which trigger changes in emotions. At the same time as these internal changes there are many external changes occurring around the adolescent. The ability for the individual to cope with daily activities such as completing academic tasks, establishing good peer relationships and gaining acceptance in their social structure are all very important aspects to an adolescent's emotional development (Larsson & Fichtel, 2014; Larsson & Sund, 2007). Studies have shown that the majority of adolescents are able to cope with emotional stressors quite well however it is estimated that 15-20% of adolescents will go through a period of subclinical depression at some point through these years (Hankin, 2008; Hankin et al., 1998).

Throughout adolescence there is constant physiological and hormonal change which can affect moodiness (Buchanan, Eccles, & Becker, 1992; Udry, 1990), as well as an increase in the amount of conflicts with parents and teachers about daily tasks increases the level of daily stress experienced through this period (Arnett, 1999; Laursen, Coy, & Collins, 1998). A longitudinal study of adolescents looked at the association between life stress and the incidence of less favorable daily emotional experiences and found that adolescents who experience more life stress reported less favorable daily emotional experiences (Larson,

Moneta, Richards, & Wilson, 2002). Therefore, a broader understanding of the various biological, psychological and social stressors which may develop through this period of adolescence gives us a deeper understanding how these interactions may affect pain experiences.

1.9 Physical Development

Physical development is measured growth and maturation. Children and adolescents mature at different rates; therefore, chronological age is not the best measure of development. For example, a child's chronological age may be 10.5 years however their skeletal maturation age may be 12.5 years, therefore physical development needs to take into account both measurements of time and maturation (Malina & Beunen, 2008). Most authors view adolescence as three distinct chronologically based phases; early adolescence (10-13 years), mid adolescence (14 to 16 years old and late adolescence (greater than 17years) (Malina & Beunen, 2008).

Growth is the increase in the size of the body as a whole or in the size of specific parts or segments of the body. Maturation is the tempo and timing of the progress towards a mature biological state (Malina & Beunen, 2008). The focus of current research in adolescence is primarily on changes in height, weight, and skeletal, sexual and somatic maturation as physical measures (Malina & Beunen, 2008) independent of pain experiences. However, early studies highlight that adolescents who have a greater rate of physical development during adolescence experience more somatic pain, which is thought to be as a result of growth spurts, altered pain perception/psychological changes or altered lifestyle (Lardon, Leboeuf-Yde, Le Scanff, & Wedderkopp, 2014; LeResche et al., 2005).

1.9.1 Puberty and Sexual Maturation. Puberty is initiated within the adolescent years as a cascade of endocrine changes lead to sexual maturity and reproductive capability.

Puberty triggers emotional, cognitive and behavioral changes as well as physical development (Patton & Viner, 2007). Puberty is a series of physical and hormonal changes that culminates in the completion of sexual development resulting in reproductive maturity (Tanner & Whitehouse, 1976). This involves the release of the hormone gonadotropin from the pituitary gland, which stimulates the sex glands (male testes and female ovaries) to produce the two sex hormones (androgens) testosterone and estrogen. It is the release of these sex hormones, which are responsible for the development of different body shapes and builds that typify the different sexes. Levels of testosterone increase muscle and bone growth whilst estrogen increases the rate of fat deposition under the skin and stimulates bone maturation (Malina & Beunen, 2008). A recent review found that there is an association between puberty and back pain, thought to be as a result of hormonal, biomechanical changes, behavioural or psychological factors within adolescents (Lardon et al., 2014).

1.9.2 Variations in Pubertal Development. Just like physical development (height and weight) there are large variations in the onset of puberty based on chronological age. This is thought to have interesting consequences when thinking about psychological development as hormonal changes have a direct affect on the adolescent brain, influencing mental state and behaviour (Michaud, Suris, & Deppen, 2006; Sisk & Foster, 2004). It is thought that body weight and adiposity have a profound influence on the onset of puberty: Undernutrition delays puberty, whereas obesity accelerates the onset of puberty (Anderson, Lyons, Giles, Price, & Estle, 2003; Santana, 2014). At the same time, there is a constant interplay between biological and environmental factors, which can impact on the onset of puberty. It has been established that both early maturation of girls and boys is a risk factor for the development of psychological and behavioral problems and we know from previous studies that changes in psychological health or behavior has an impact on pain experiences in adolescents (Barlow et al., 2014; Eccleston et al., 2014; Ferguson, 2013). Thus, evaluating

these interactions between the biopsychosocial predictors of somatic pain experiences in adolescence is important and is the aim of the current study.

1.9.3 Physical Development and Somatic Pain. Physical development has been associated with some somatic pains in adolescents. A study found a correlation between increased pubertal development and the presence of back pain throughout adolescence (LeResche et al., 2005). Incidence of back pain increased from 6% before puberty and rose to 31% and 36% post puberty for boys and girls respectively (LeResche et al., 2005). Interestingly, for stomach-ache rates were 22% before puberty and declined to 16% for boys, but increased to 29% for girls (LeResche et al., 2005). There was an increase in the number of multiple pain types related to increased pubertal development, which was greater for girls than boys(LeResche et al., 2005). Similarly a recent systematic literature review identified puberty as having a moderate association with back pain in adolescents (Lardon et al., 2014). However, causal mechanisms have not been identified between pubertal development and somatic pain. Broader understandings of biological, psychological and social factors will allow better formulated questions around pain experiences in adolescence.

1.10 Social and Environmental Predictors

Studies in twins have analysed widespread pain in adolescents aged 11 years old and found that genetic factors seem to have a minor role in pain experiences, accounting for only 10% of the total variance (Mikkelsson, Kaprio, Salminen, Pulkkinen, & Rose, 2001). The authors found that shared environmental circumstances were considered to be more

influential to the adolescent pain experiences (Mikkelsson et al., 2001; Von Baeyer & Champion, 2011). Social and environmental predictors include socioeconomic disadvantage, issues with family relationships, poor education standards or bullying. Socioeconomic status disadvantage has been associated with poor health inequalities including pain frequency, engaging in risky behaviours earlier (alcohol consumption and smoking) and bullying (Due et al., 2011). Socioeconomic status (SES) is calculated from income level, level of education, occupation and material deprivation of the parents (Due et al., 2011; Torsheim et al., 2004).

1.10.1 Material Deprivation. Material deprivation is defined as the enforced lack of (or inability to afford, when desired) items and activities such as washing machines, TV, telephone, car or holidays (Deutsch, Guio, Pomati, & Silber, 2014). Traditionally, the SES of adolescents is classified according to the status based on the head of the household, parental income, material deprivation, level of education or occupation (Torsheim et al., 2004). This status will vary dramatically between different community groups within a given population. The external factors of health according to the World Health Organisation are "the conditions in which people are born, grow, live, work and age" (WHO, 2016). The level of material wealth varies significantly between communities, which affects the general quality of housing, access to health care and education (Torsheim et al., 2004). Changes in SES is a major determinant of inequality and show that growing up in an impoverished or marginalised socioeconomic conditions shortens the lifespan and contributes to poor mental and physical health such as somatic pain (Elgar et al., 2015).

Adolescents who live in deprived countries had a higher risk of self-rated poor health, including pain during early adolescence than those in less deprived countries (Torsheim et al., 2004). Globally there has been an increase in the socioeconomic status gap for adolescents mental and physical health from 2002 to 2010 (Elgar et al., 2015). In an Australian study, children aged 4 to 17 years who came from lower socioeconomic backgrounds were reported

to have more negative experiences of health, such as emotional problems and physical illness compared to those from higher socioeconomic backgrounds. (Spurrier, Sawyer, Clark, & Baghurst, 2003). Similarly, lower SES has been linked to higher frequencies of pain experiences in adolescence (King et al., 2011). Therefore, external social predictors such as material deprivation, school experiences and bullying shape the overall health experience of the adolescent and it is important to explore these relationships to understand the adolescent pain experience.

1.10.2 Material Deprivation Relating to Health Behaviours. Material deprivation as one of the factors contributing to the social predictors of health is important in the adolescent population. Studies have shown that material deprivation as a subcomponent of socioeconomic status has a strong relationship with health status in particular pain (Torsheim et al., 2004). It is thought that these relationships operate through a stressor reaction manifesting as emotional and/or physical symptoms such as pain (Ottova et al., 2012). Therefore, it is important to look at material deprivation in association with self-rated poor health complaints within the larger biopsychosocial theoretical framework. One study found that familial wealth as reported by the adolescent was a strong predictor of quality of life (Von Rueden, Gosch, Rajmil, Bisegger, & Ravens-Sieberer, 2006). Whilst low familial wealth has been shown to be associated with increased pain frequency, poor psychological and emotional state, relationships with peers and the development of poor social networks (Von Rueden et al., 2006). Therefore, exploring SES status, relationships with parents and peers and the school environment is important in understanding the social and environmental factors of adolescence as a potential predictor of somatic pain (Due et al., 2011).

1.10.3 Relationships with Parents / Peers. As discussed above the sense of community and quality of relationships is pivotal in developing favorable health outcomes in

adolescents. Well-established social connections are shown to serve as protective factors for adolescents with health complaints including somatic pain, smoking and alcoholism (Viner et al., 2012). Existing life course models identify that supportive parenting along with appropriate education in childhood to adolescence provides preventative strategies for the development of health inequalities (Viner et al., 2012). Emerging research also indicates connections with school including satisfaction and relationships with peers protects against some wide range health inequalities such as pain (Anteghini, Fonseca, Ireland, & Blum, 2001; Blum et al., 2003). These are social predictors which are important to explore as adolescence is a key period for the adoption of healthy behaviours, which are protective across the life course for conditions such as somatic pain (Mackenbach et al., 2008; Viner et al., 2012).

1.10.4 Social Factors and Somatic Pain. Social predictors are important in the adolescent years as it is thought that material deprivation, family and peer relationships and connectedness to community impact health experiences such as somatic pain and mood disorders (Due et al., 2011; Mackenbach et al., 2008; Nielsen et al., 2015; Viner et al., 2012). The relationship between social constructs and somatic pain is thought to be a reaction to stressors. It is known that frequent stresses such as parental conflicts, bullying, lack of support by parents, peers or teachers as well as economic inequality have an affect on emotional state and pain frequency through stress (Brosschot, 2002; Ottova et al., 2012; Thayer & Brosschot, 2005). This theory is strengthened with a recent study showing that having a connectedness to parents and peers is an important protective factor against health inequalities including pain (Viner et al., 2012). Findings are largely inconsistent within an Australian population and therefore a broader understanding of the social stressors which may develop through this period of adolescence to enable a deeper understanding of how these interactions may affect pain experiences.

1.11 Summary and Current Study

There are many different factors which can affect pain in adolescents including pubertal development, psychological and social / environmental factors. We can use the biopsychosocial model as an integrative framework to help understand these complex relationships. The biopsychosocial model posits that biological, psychological and social factors play an important role in individuals' functioning within the context of health conditions in particular somatic pain (Due et al., 2011; King et al., 2011; Kröner-Herwig et al., 2011). It is thought that the complex interactions of these factors are learnt and developed during adolescence (Viner et al., 2012), with the established relationships between emotional state and somatic pain states remaining into adulthood.

Within adult populations there is a wealth of understanding between these centrally processed connections manifested as somatic pain in multiple locations (Wessely & White, 2004; Whitehead, Palsson, & Jones, 2002). However, they are often treated as individual locations of pain as a result of the focus of individual disciplines for example a neurologist studies headache, a gastroenterologist studies abdominal pain and a physiotherapist / chiropractor studies back pain (Von Baeyer & Champion, 2011). However, recent epidemiological studies have suggested that the majority of adolescents who experience one pain also experience pain in more than one location over time (Kröner-Herwig et al., 2011). Thus, it is possible that there are common links related to biological, psychological and social stressors within an adolescent population affecting somatic pain (Brosschot, 2002; Ottova et al., 2012).

Studies suggest that somatic pain is an indicator for poor mental health (Ando et al., 2013) and there are studies linking poor mental health and/or negative mood states with increased pain (Eccleston et al., 2014). We know from international surveys that girls are

more likely to experience pain with headache being the most common somatic pain type (Swain et al., 2014). However, we do not know how associations between biological, psychological and social predictors influence somatic pain in Australian adolescents and whether these relationships differ for boys and girls.

In summary, understanding adolescents' experience of somatic pain in relation to the impact that psychological, biological and social factors have on through this period of life is important for individuals, clinicians, researchers and policy makers. While previous research has looked at these areas in isolation no research has effectively looked at the association of biological, psychological and social predictors associated with somatic pain within an Australian adolescent population which is the aim of this study.

1.12 Study Aims and Hypothesis

Primary aim. The overarching aim of this is to develop further understanding of the somatic pain experience in Australian adolescents. After a comprehensive search of the literature, it is not yet fully understood how interactions and associations of an adolescents biological, psychological and social factors influence somatic pain conditions such as headache, stomachache and backache, in Australian adolescents.

Aim One. To investigate the association between somatic pain disorders (stomach ache, headache and backache) associated with physical development, psychological health and/or social predictors in Australian adolescents

Hypothesis 1a. There is an association between physical development, psychological health and social predictors with somatic pain frequency.

Hypothesis 1b. There will be a stronger association between somatic pain and factors of physical development, psychological health and social predictors in girls than boys

Aim Two. The purpose is to identify the potential predictors independently and additively that predict the level of somatic burden for both boys and girls.

Aim Three. To investigate whether the association between emotional state and somatic pain disorders are moderated by social predictors and pubertal development for boys and girls

Hypothesis 3a. Negative emotional state will more strongly, positively predict somatic pain for adolescents with a worse relationship with peers (greater support of friends, greater conflict with friends and greater levels of bullying)

Hypothesis 3b. Negative emotional state will more strongly, positively predict somatic pain for adolescents with greater missed school and less school satisfaction

Hypothesis 3c. Negative emotional state will more strongly, positively predict somatic pain for girls with greater pubertal development stage compared to boys.

Hypothesis 3d. Negative emotional state will more strongly, positively predict somatic pain for adolescents with greater material deprivation and lower SES status

Aim Four. To investigate the direct and indirect effects of psychosocial and pubertal development predictors on the relationship between emotional state and somatic pains for both boys and girls

Aim 4a: Among the psychosocial variables found to be statistically independently associated with headache, we aim to measure associations directly and indirectly through emotional state.

Aim 4b: Among the psychosocial variables found to be statistically independently associated with stomach-ache, we aim to measure associations directly and indirectly through emotional state.

Aim 4c: Among the psychosocial and pubertal development variables found to be statistically independently associated with backache, we aim to measure associations directly and indirectly through emotional state.

Aim 4d: Among the psychosocial variables found to be statistically independently associated with somatic pain, we aim to measure associations directly and indirectly through emotional state.

In evaluating these aims and hypotheses we will have a better understanding of biological, psychological and social predictors on the evolution of somatic pain in adolescents. While this understanding will be incomplete, it will provide useful input into the design of future, prospective studies.

Chapter Two – Methods

2.1 Study Design, Setting, Participants

A secondary analysis of data was conducted via collaboration with The Australian Child Wellbeing Project (ACWP) http://australianchildwellbeing.com.au/. The sample consisted of a large nationally representative study of Australian adolescent school children (including Aboriginal and Torres Straight Islanders) between the ages of 8 -14 years.

An online in-class quantitative survey was established for children in years 4, 6 and 8 from 180 primary and secondary schools in every state and territory in Australia. The Australia Council for Educational Research led the collection of data in the second half of 2014. Schools were approached to participate and informed consent was obtained from guardians and children. Students took approximately 20-30 minutes to complete the survey within school hours. The survey was based on variables established from in-depth group work and interviews of 8 -14 year olds lead by The Social Policy Research Centre at the University of New South Wales and Flinders University in South Australia. Our secondary analysis of the data collected from this project was approved by Macquarie Universities Human Research Ethics Committee (5201600085) (Appendix A).

2.2 Variables and Measurement

The survey consisted of a series of demographic, health behavior and social questions. The demographic questions included: gender, year at school and Aboriginal or Torres Strait Islander background. Children in year 4 were excluded from analysis due to not being part of the adolescent age definition between ages 10-19 years (WHO, 2016). The oucome variables were questions about somatic pain frequency for three types: headache, stomachache and backache. Exposure variables included were questions about psychological health, pubertal

development and social context which were determined from the background literature review shown in table 1.

2.2.1 Somatic Pains – Headache, Stomach-ache and Backache. The somatic pain questions were adapted from the Health Behaviours in School Aged Children's symptom checklist (HBSC-SCL) (Gariepy, McKinnon, Sentenac, & Elgar, 2015). Respondents were asked to rate the frequency of each of the three somatic pain conditions experienced within the last 6-months; headache, stomach-ache and backache. Each item was assessed individually on a reversed 5-point scale ranging from rarely or never to daily (1= *rarely or never,* 2=*about every month,* 3= *about every week,* 4= *more than once a week and* 5=*about everyday*). In addition, the three somatic pain types were aggregated to give a somatic pain summary score out of 15, with higher scores indicating a higher frequency of somatic pain types. Items that measured negative dimensions of physical health functioning were reverse-coded such that higher scores on any of the items indicated poorer physical health functioning (Gariepy et al., 2015). The total somatic pain score had adequate reliability or internal consistency (Cronbach's $\alpha = .741$) in the current study. This is consistent with previous research (intraclass correlation coefficients between 0.67 – 0.71) for headache, stomach-ache and backache (Haugland & Wold, 2001).

2.2.2 Psychological Development

Emotional State / Mood Score. Psychological health measured via a question about the emotional state of the individual based on the HBSC-SCL which has been validated to measure psychological health in school aged children (Gariepy et al., 2015). Respondents were asked to rate the frequency of 4 psychological symptoms experienced in the last 6 months; feeling low, irritability or bad tempered, feeling nervous and difficulty getting to sleep. Each item was assessed on a reversed 5-point scale ranging from rarely or never to

daily (1= *rarely or never,* 2=*about every month,* 3= *about every week,* 4= *more than once a week and* 5=*about everyday*). Items that measured negative dimensions of emotional state was reverse coded such that higher scores indicate poorer emotional state. The emotional score has shown strong reliability or internal consistency (Cronbach's α=0.80). This aligns with the internal validity of the psychological subscale in school-aged children (Cronbach's α=0.78) (Gariepy et al., 2015). The 4-item subscale demonstrated convergent validity with indicators for emotional problems ($r = -.79$, $p<0.001$) and emotional well-being ($r = .48$, $p<0.001$), and discriminant validity with indicators for behavioral problems ($r = -.17$, $p<0.001$) and prosocial behavior ($r = .20$, $p<0.001$) (Gariepy et al., 2015).

Subjective Health. Subjective health was measured from a single item question from the Health Behaviours in School Aged Children study which has been validated as a measure of increased mortality risks associated with health status (Idler & Benyamini, 1997). Respondents were asked 'would you say your health is…' on a 4-item response scale ranging from (1=*excellent*, 2=*good*, 3=*fair*, 4=*poor*).

Cantril Quality of Life. A cantril quality of life score was based of a 10-point scale which is displayed as a ladder in the survey asking students 'where on the ladder do you feel you stand at the moment'. Scores ranged from 0=*worst life possible* to 10=*best possibly life* (Cantril, 1965). The cantril quality of life scale has been a validated measure of psychological health within the literature with Kappa's being of weak convergent validity, ranging from 0.30 to 0.39 (Levin & Currie, 2014).

Life Satisfaction. A life satisfaction (LS) score was used as an additional measure of psychological health. Respondents were asked whether they agreed or disagreed with the following 6-items; my life is going well, my life is just right, I wish I had a different kind of life, I have a good life, I have what I want in life and I feel positive about the future. Each

item was assessed on a 6-point scale ranging from strongly disagree to agree (1=*strongly disagree*, 2= *disagree*, 3=*neither agree or disagree* 4=*agree*, 5= *agree* and 6=*I don't know*) with the question 'I wish I had a different kind of life' reverse coded to follow the same scale before being added together. Responses of 'I don't know' were treated as missing and excluded from analysis for the reasons of making the summary score. Items were summed for a total score and divided by 6 to create a mean score (Huebner, 1991). Using this rating scale, total scores range from 5-25, a high score on the life satisfaction summary score is indicative of high LS, and low scores are indicative of low LS. The LS score has shown strong reliability or internal consistency (Cronbach's α=0.85) in the current study. This is in line with current reliability studies showing a (Cronbach's α=0.82) (Huebner, 1991).

2.2.3 Pubertal Development

Pubertal Developmental Stage (Puberty). Pubertal development status was measured from the Self-Administered Rating Scale for Pubertal Development (Carskadon & Acebo, 1993). Items were separated for boys and girls specific to their respective stages of pubertal development and were only answered by adolescents in years 6 and 8. Boys were asked to answer 5 items: tailored to Boys stages of development; would you say that your growth in height, would you say that your body hair growth, have you noticed any skin changes, especially pimples, have you noticed a deepening of your voice and have you began to grow hair on your face. Girls were asked to answer 4 items: would you say that your growth in height, would you say that your body hair growth, have you noticed any skin changes, especially pimples, have you noticed that your breasts have begun to grow. Respondents were asked to rate these items on a 5-point scale from not yet started to I don't know (1=*not yet started,* 2=*barely started,* 3=*definitely started* 4= *seems complete* 5=*I don't know*). Responses of 'I don't know' were treated as missing and excluded from analysis for the reasons of making the summary score. The four items for boys, and five items for girls, were averaged

to give a mean summary score for both boy's (Cronbach's α=0.83) and girls (Cronbach's α=0.74) physical development. This aligns with the reliability of the self-administered pubertal development scale in school-aged children (Cronbach's α= 0.67 to 0.70) (Carskadon & Acebo, 1993).

Menstrual Status. Girls also had a separate question about the onset of menses with the response options of 1. *Yes*, 2. *No* and 0. *I don't know*. This was included as a separate variable in addition to the pubertal development stage as another measure of girls' pubertal development.

2.2.4 Social and Environmental Predictors

Material Deprivation. Material deprivation was measured by asking respondents to answer 5 items based on validated items; including an iPod or other personal music player, some money that you can save each month, either in a bank or at home, the right kind of clothes to fit in with other people your age, my family has enough money for me to go to school camp and your own mobile phone. The response options were (1= *I have this,* 2 = *I don't have this but would like it,* 3 = *I don't have this and I don't want or need it*). A material deprivation scale was then created by adding together the number of items lacked and wanted by respondents, resulting in a 0–5 scale with 0 indicating no deprivation and 5 indicating the highest level of deprivation possible within this index. The material deprivation measure has shown low reliability (Cronbach's α=0.45) in the current study. This is in contrast to previous research (Cronbach's α= 0.72) (Main & Bradshaw, 2012).

Socioeconomic Status (SES) Deprivation. In accordance with the ACWP method, SES deprivation was measured using the question "Does your family have enough money to put petrol in the car?". The responses options for SES deprivation were 1= *yes* and 2= *no*.

Support of Closest Friends. Support of friends was measures using four questions about the support of closest friends Respondents were asked to think aspects of close friend support: 1) I spend fun time with this person, 2) I share private thoughts and feelings with this person, 3) I depend on this person for help, advice and support, 4) this person sticks up for me. Response options included a scale from never or hardly ever to always or almost always (1= *never or hardly ever to* 5=*always or almost always*). The four items were summed to give a summary score out of 20 for support of closest friends where lower scores are associated with less support which is based of validated measures (Waldrip, Malcolm, & Jensen-Campbell, 2008). The support of closest friends score has shown strong reliability or internal consistency (Cronbach's α=0.79) in the current study. This aligns with the reliability of the support of closest friends scale (Cronbach's α= 0.87 to 0.93) (Waldrip et al., 2008).

Conflict of Closest Friends. Conflict with closest friends was based from 4 items; I get into fights with my friend, my friend bugs me or annoys me even though I ask him/her not to, my friend and I argue and my friend and I disagree about many things. Response options including a scale from never or hardly ever to always or almost always (1= *never or hardly ever to* 5=*always or almost always*). The four items were summed to give a mean summary score out of 20 for conflict with closest friends where higher scores are associated with more conflict with friends. Conflict with friends is based on validated measures (Bukowski & et al., 1994). The conflict of closest friends score has shown strong reliability or internal consistency (Cronbach's α=0.83) in the current study. This aligns with the reliability of the conflict of closest friends scale (Cronbach's α=0.77) (Bukowski & et al., 1994).

Bullying. For the measurement of bullying, respondents were asked to think about their experiences with bullying over the last term at school and respond to 6 items; students deliberately ignored or left me out of a group to hurt me, I was teased in nasty ways, I had a

student tell lies about me behind my back, to make other students not like me, I've been made to feel afraid I would get hurt, I had secrets told about me behind my back to hurt me and a group decided to hurt me by ganging up on me. Response options include (1= *this did not happen to me this term*, 2= *once or twice this term* 3= *every few weeks this term* 4= *about once a week this term* 5= *several times a week or more this term*). A bullying score was calculated by taking a mean score of the 6 items with higher scores being related to higher levels of bullying (Cross, 2009). The bullying score has shown strong reliability or internal consistency (Cronbach's α=0.91) in the current study which is consistent with previous research (Cross, 2009).

School Satisfaction. In the measurement of school satisfaction, respondents were asked about their experiences at school to 6 statements; I feel happy, I really like to go each day, I find learning is a lot of fun, I feel safe and secure, I like learning, I get enjoyment from being there. Response options were from a 4- item scale (1=*strongly disagree,* 2=*disagree,* 3=*agree,* 4=*strongly agree*). Items were summed for a total score and divided by six to create a mean score. Using this rating scale, total scores range from 6–24 as a validated measure of school satisfaction from the Longitudinal of Australian Children Questionnaires with lower scores equaling poorer school satisfaction (Forrest & Edwards, 2014). The school satisfaction score has shown strong reliability or internal consistency (Cronbach's α=0.91) in the current study. This aligns with the reliability of the school satisfaction scale (Cronbach's α=0.77) (Forrest & Edwards, 2014). Similarly, school pressure was analysed by asking respondents to think about pressure to complete schoolwork. Response options were (1= *not at all*, 2= *a little*, 3= some, 4=*a lot*).

Missed School. Missed school last term was measures on respondents' responses on a 6 item scale (1=*never*, 2=*hardly ever*, 3=*about once a week*, 4=*most days*, 5=*every day* and

6=*don't know*). Responses of 'I don't know' were treated as missing and excluded from analysis for the reasons of making the summary score. The five items will be averaged to given a mean summary score for missed days of school with higher scores equaling more missed school (Rees, Andresen, & Bradshaw, 2016).

2.3 Statistical Analysis

Data was analysed using IBM Statistics SPSS v23 and AMOS v23. Descriptive analyses of participants were stratified by gender to explore hypothesized differences between boys and girls. Demographics such as year at school, gender and Aboriginal and Torres Strait Islander were summarized using counts and percentages (%) for qualitative variables. Whereas quantitative variables are reported as means (M) and standard deviation (SD). Missing data or answers of 'I don't know' were removed by the authors when establishing summary scores of variables. Distribution of data were analysed via test for skewness and kurtosis. The Spearman Rho for correlation analysis and Kruskal-Wallis Test for comparing discrete groups were used as the data was not normally distributed. To further evaluate differences between boys and girls simple linear regression was performed for all exposure variables and somatic pains. To identify which exposure variables were most significantly associated with somatic pains a multiple linear regression with backward elimination was used to identify most significant predictors of somatic pain. The assumption of normality was violated, thus bootstrapped p-values were calculated.

2.3.1 Statistical Analysis for Aim One.

Hypothesis 1a Calculation of Correlation. Evaluation of the individual relationships between biological, psychological, social predictors with somatic pain types and a combined summary score.

For quantitative predictors such as bullying score and for ordinal scaled variables such as SEIFA correlation analysis was conducted using the spearman rank correlation for each sample due to deviations from the assumption of bivariate normality assumed by the p-value associated with the Pearson correlation coefficient. As girls menstrual status is a nominal scaled variable

Hypothesis 1b Stratified by Gender. Hypothesis 1b will be analyzed using simple linear regression analysis for the individual independent variables associated with each somatic pain type (headache, stomach-ache, backache and somatic pain score). Measures of R^2, standardised coefficient beta, t-test and p-values will be used to determine the level of association between individual independent variables and somatic pain for each gender.

2.3.2 Statistical Analysis for Aim Two.

Aim 2 will be analysed using a backward elimination regression to identify factors most predictive of somatic pain types stratified by gender. Independent biological, psychological and social variables (p=<.05) will be included in further analysis. Multiple linear regression was calculated for each independent variable meeting the (p=<.05) criteria. These were then tabulated as R^2, 95% confidence interval, standardised beta, t-test, bootstrapped p-values and squared part correlation for significant biological, psychological and social variable was calculated for each somatic pain type stratified by gender.

2.3.3 Statistical Analysis for Aim Three.

Hypothesis 3a Moderating Effect of Relationships with Peers. For boys and girls individually the possible moderators of the relationship between emotional state and somatic pain types was evaluated through an interaction term formed by the product of a potential moderator (support of friend, conflict of friends and bullying) and emotional state. The hypotheses were tested using the statistical significance of the interaction term (t-statistic and p-value) and also by interpreting the effect sizes (R^2, unstandardised and standardised beta

and 95% confidence intervals). Unique variance explained by the interaction term was calculated as the squared part correlation.

Hypothesis 3b Moderating Effects of School Based Variables. For boys and girls individually the possible moderators of the relationship between emotional state and somatic pain types was evaluated through an interaction term formed by the product of a potential moderator (school satisfaction and missed school) and emotional state. The hypotheses were tested using the statistical significance of the interaction term (t-statistic and p-value) and also by interpreting the effect sizes (R^2, unstandardised and standardised beta and 95% confidence intervals). Unique variance explained by the interaction term was calculated as the squared part correlation.

Hypothesis 3c Moderating Effects of Pubertal Development in Girls. For boys and girls individually the possible moderators of the relationship between emotional state and somatic pain types was evaluated through an interaction term formed by the product of a potential moderator (pubertal development) and emotional state. The hypotheses were tested using the statistical significance of the interaction term (t-statistic and p-value) and also by interpreting the effect sizes (R^2, unstandardised and standardised beta and 95% confidence intervals). Unique variance explained by the interaction term was calculated as the squared part correlation.

Hypothesis 3d Moderating Effects of Material and SES Deprivation. For boys and girls individually the possible moderations of the relationship between emotional state and somatic pain types was evaluated through an interaction term formed by the product of a potential moderator (material deprivation and SES deprivation) and emotional state. The hypotheses were tested using the statistical significance of the interaction term (t-statistic and p-value) and also by interpreting the effect sizes (R^2, unstandardised and standardised beta and 95%

confidence intervals). Unique variance explained by the interaction term were calculated as the squared part correlation.

2.3.4 Statistical Analysis for Aim Four.

The purpose of this aim was to investigate the hypothesized direct and indirect relationships between relationships with peers, school environment, pubertal development, socioeconomic deprivation and individual somatic pain measures (headache, stomach-ache, backache and somatic pain) through emotional state. In particular, we sought to understand the relative magnitude of these paths. Path modelling of a combination of key elements based on previously identified significant variables from hypothesis 1c was carried out using AMOS (v23) software. Any missing data was excluded from the models. Path-coefficients and model fit statistics were then tabulated for the direct, indirect and total effects between variables. The models for Aim 4a – d showed adequate fit under the standard criteria of Chi-Squared value/df<5, TLI>.95, CFI>.95 and RMSEA <.05 (Schermelleh-Engel, Moosbrugger, & Müller, 2003).

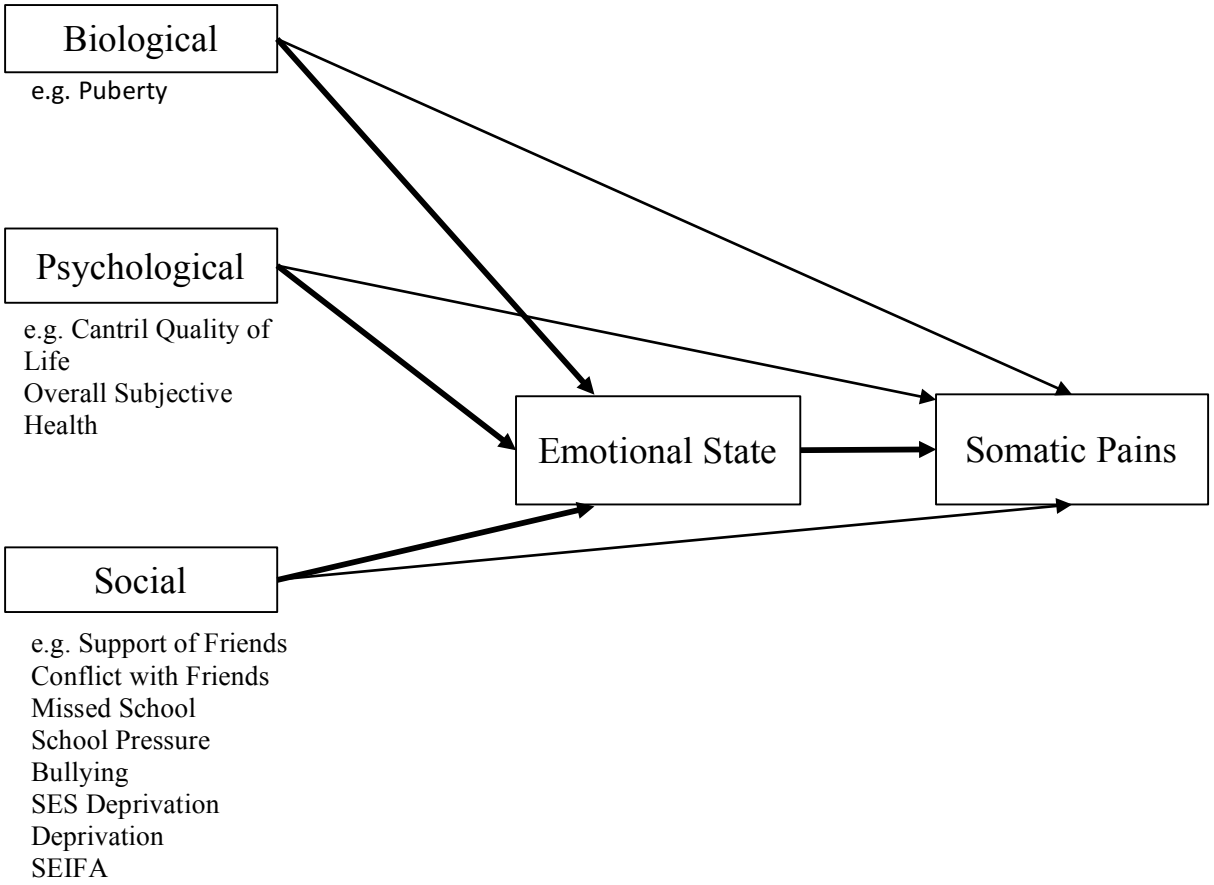
Aim 4a Headache. Aim 2 identified which predictors were important in explaining headache for boys and girls separately. Based off the results of these analyses only the significant risk factors were chosen to be included in the path model for aim 4a. Out of the total responses there were 292 boys and 336 girls missing for headache. These responses were excluded and we were left with 1905 boys and 2039 girls. Path analysis was conducted for each model separately for boys and girls. For boys and girls psychosocial variables identified in aim 2 were used as illustrated in figure 2a and b. The overall model is shown in table 6a shows the direct, indirect and total effects via path coefficients with bootstrapped standard errors due to violation of the multivariate normal assumption and p-values calculated from z-scores.

Aim 4b Stomach-ache. Aim 2 identified which predictors were important in explaining stomach-ache for boys and girls separately. Based off the results of these analysis only the significant risk factors were chosen to be included in the path model for aim 4b. Out of the total responses there were 330 boys and 314 girls missing for stomach-ache. These responses were excluded and we were left with 1867 boys and 2061 girls. Path analysis was conducted for each model separately for boys and girls. For boys and girls psychosocial variables identified in aim 2 were used as illustrated in figure 3a and 3b. The overall model as shown in table 6b shows the direct, indirect and total effects via path coefficients with bootstrapped standard errors due to violation of the multivariate normal assumption and p-values calculated from z-scores.

Aim 4c Backache. Aim 2 identified which predictors were important in explaining backache for boys and girls separately. Based off the results of these analysis only the significant risk factors were chosen to be included in the path model for aim 4c. Out of the total responses there were 353 boys and 319 girls missing for backache. These responses were excluded and we were left with 1844 boys and 2056 girls. Path analysis was conducted for each model separately for boys and girls. For boys psychosocial and pubertal development variables identified in aim 2 were used as illustrated in figure 4a. For girls psychosocial variables identified in aim 2 as illustrated in figure 4b. The overall model as shown in table 6c shows the direct, indirect and total effects via path coefficients with bootstrapped standard errors due to violation of the multivariate normal assumption and p-values calculated from z-scores.

Aim 4d Somatic Pain. Aim 2 identified which predictors were important in explaining headache for boys and girls separately. Based off the results of these analysis only the significant risk factors were chosen to be included in the path model for aim 4d. Out of the

total responses there were 288 boys and 343 girls missing for somatic pain. These responses were excluded and we were left with 1909 boys and 2032 girls. Path analysis was conducted for each model separately for boys and girls. For boys and girls psychosocial variables identified in aim 2 were used as illustrated in figure 5a and 5b. The overall model as shown in table 6d shows the direct, indirect and total effects via path coefficients with bootstrapped standard errors due to violation of the multivariate normal assumption and p-values calculated from z-scores.



(*Figure 1* – Describes the base path model showing the direct (purple) and indirect (red) effects of biopsychosocial predictors on somatic pains through emotional state)

Chapter Three - Results:

3.1 Descriptive Statistics

The participants were a representative random sample of Australian adolescents. Shown in Table 1 are descriptive statistics mean (M) and standard deviations (SD) for the individual variables. The total sample size is 4,572 adolescents in years 6 (18%) and 8 (82%). An equal proportion of boys and girls is presented in the sample (boys 48%, girls 52%). Aboriginal and Torres Strait Islanders make up only 4.0% of the total population sampled which is slightly higher than the total national average of 3% (Linacre, 2004).

The majority of children experience low levels of total somatic pain (M = 6.00 out of a maximum of 15 and SD = 2.90) and the majority of children rate their overall subjective health as being well (M = 3.25 and SD = 0.66). Amongst the somatic pain conditions headache was the most common form of somatic pain (M = 2.18 and SD = 1.20) experienced by Australian adolescents about once per month on average. Emotional state was similarly distributed with the majority of adolescents rating their emotional state as being well (M = 8.90 and SD = 4.20).

In this study, Australian adolescents experienced moderate levels of bullying over the last term (M = 8.73 out of a maximum of 20 and SD = 4.54). Based on the SEIFA there is a good spread of adolescents from across low (18%), middle (37%) and high (45%) socioeconomically based schools. The majority of adolescents rated their missed school as hardly ever last term (M = 1.99 out of a maximum of 5 and SD = 6.66) and had high life satisfaction (M = 24.20 out of a maximum of 25 and SD = 4.27).

3.2 Normality of Measures

Analysis of the distribution of individual variables was performed through skewness and kurtosis measures. Results shown in Table 1 suggest that14 out 16 variables are not normally distributed. Positive skewness was seen in variables such as bullying (S = 2.48) and material deprivation (S = 1.86). Negative skewness was seen in variables such as SES deprivation (S = -7.77), life satisfaction (S= -.985) and support of closest friends (S= -.084). Kurtosis measurements were calculated showing a large sharpness of peaks for socioeconomic deprivation (K = 58.45 SE = 0.07) and bullying (K = 6.42 SE = 0.07).

A large majority of variables were not normally distributed. Therefore, Spearman – Rho correlation analysis for non-parametric data was used to calculate correlation coefficients and p-values for each individual independent variable for each somatic pain type to address hypothesis 1a. The Kruskal Wallis test was used to evaluate association between menstruation and pain due to violations in assumptions of normality. Respondents of ‘I don’t know’ were also included in table one showing 26% of girls were not sure if menses had started yet.

Table 1

Descriptive Statistics

Variable	Response	N (%)		Total Sample					
				M (*SD*)		Skew (SE)		Kurt (SE)	
Gender	Boys	2197	(48)						
	Girls	2375	(52)						
Year Survey	6	809	(18)						
	8	3763	(82)						
Aboriginal & Torres Strait Islanders		176	(4.0)						
Overall Subjective Health				3.25	(0.66)	-0.56	(0.04)	0.39	(0.07)
Cantril Quality of Life				7.66	(1.68)	-0.99	(0.04)	1.55	(0.07)
Life Satisfaction				24.20	(4.27)	-.985	(0.04)	1.19	(0.07)
Material Deprivation				0.11	(0.17)	1.86	(0.04)	3.94	(0.07)
SES Deprivation	No	71	(2)						
	Yes	4428	(98)						
Missed School Last Term				1.99	(6.66)	1.13	(0.04)	3.44	(0.08)
Support of Closest friends				15.75	(3.80)	-0.84	(0.04)	0.10	(0.07)
Friends Conflict				6.80	(3.26)	1.62	(0.04)	2.80	(0.07)
School Satisfaction				17.08	(3.90)	-0.52	(0.04)	0.52	(0.07)
School Pressure				2.60	(0.90)	.090	(0.04)	-0.83	(0.07)
Bullying				8.73	(4.54)	2.48	(0.04)	6.42	(0.07)
SEIFA	Low	830	(18)				(0.04)		(0.07)
	Middle	1685	(37)			-0.48		-1.08	
	High	2057	(45)						
Pubertal Development	Boys			2.51	(0.61)	-0.36	(0.05)	-0.8	(0.11)
	Girls			2.78	(0.59)	-0.50	(0.05)	0.42	(0.11)
Menstruation	No	553	(25)						
	Yes	1077	(49)						
	I don't know	577	(26)						
Somatic Pain Score				6.00	(2.90)	1.1	(0.04)	0.62	(0.07)
Headache				2.18	(1.20)	0.78	(0.04)	-0.47	(0.07)
Stomach-ache				1.90	(1.10)	1.21	(0.04)	0.74	(0.07)
Backache				1.91	(1.20)	1.24	(0.04)	0.38	(0.07)
Emotional State				8.90	(4.20)	0.85	(0.04)	-0.07	(0.07)

3.3 Results for Aim One: To investigate the association between somatic pain disorders (stomach ache, headache and backache) and physical development, psychological health and/or social predictors in Australian adolescents

Hypothesis 1a*:* There is an association between physical development, psychological health and social predictors with somatic pain frequency.

Hypothesis 1a is supported with a strong association between emotional state and all somatic pains as shown in Table 2. Correlations were strongest for emotional state and somatic pain score *rho* = .639, p <.001. Likewise, there were strong associations between emotional state and headache *rho* =.543, p <.000, stomach-ache *rho* =.529, p <.001 and backache *rho* =.475, p = .001.

Table 2

Correlation Analysis

Variable		Total			
		Headache	Stomach ache	Backache	Somatic Score
Student gender	Rho	.084**	.136**	.065**	.117**
Year survey	Rho	.046**	.039*	.096***	.067***
Aboriginal and/or Torres Strait Islander	Rho	0.022	0.021	0.029	0.027
Overall subjective health	Rho	-.170**	-.150**	-.121**	-.184**
Cantril ladder quality of life	Rho	-.240**	-.208**	-.193**	-.265**
Life Satisfaction	Rho	-.241**	-.218**	-.211**	-.279**
Deprivation	Rho	.070**	.071**	.076**	.093**
SES deprivation-petrol	Rho	-.079**	-.069**	-.076**	-.088**
Missed school last term	Rho	.155***	.148***	.132***	.177***
Support of friends	Rho	-0.011	0.025	0.003	0.004
Conflict of Friends	Rho	.121**	.138**	.122**	.161**
School Satisfaction	Rho	-.253**	-.222**	-.230**	-.288**
School Pressure	Rho	.193**	.173**	.188**	.229**
Bullying	Rho	.254**	.245**	.220**	.297**
National SEIFA level of student school	Rho	0.003	-0.005	-0.007	0.001
Emotional State	Rho	.543***	.529***	.475***	.639***
Boys Puberty	Rho	-0.019	-0.009	.075***	0.021
Girls Puberty	Rho	.089**	.082**	.097**	.110**
Menstruation	Yes	2.40 (1.27)	2.15 (1.10)	2.09 (1.29)	6.65 (3.00)
	No	2.19 (1.23)	1.90 (1.10)	1.91 (1.20)	6.03 (2.87)
	I Don't Know	2.16 (1.25)	1.91 (1.10)	1.85 (1.26)	5.92 (2.98)
	P - value	3.27 (0.51)	3.20 (0.53)	10.10 (0.04)	1.84 (0.40)

Note. * $p < .05$ ** $p < .01$ *** $p < .001$

Social variables such as bullying were weakly associated with somatic pain *rho*=.297, p = .001, headache *rho* = .254, p = .001, stomach-ache *rho* = .245, p = .001 and backache *rho* =.220, p = .001 seen in Table 2. Missed school last term seems to also be weakly correlated with somatic pain *rho* = .177, p <.001, headache *rho* = .155, p <.001, stomach-ache *rho* = .148, p <.001 and backache *rho* = .132, p <.001. Other social variables such as school satisfaction is negatively associated with somatic pain *rho* = - .288, p = .001, headache *rho* = -.253, p = .001, stomach-ache *rho* = -.222, p = .001 and backache *rho* = -.230, p = .001.

There were weak correlations between pubertal development and somatic pain *rho*=.110, p = .001, headache rho = .089, p = .001, stomach-ache rho = .082, p = .001 and backache rho = .097, p=.001 seen in table 2. However, this was not the same for boys with a weak association between puberty and backache rho = .075, p = .001, which may only be significant as a result of a large sample size.

Hypothesis 1b. There will be a stronger association between somatic pain and factors of physical development, psychological health and social predictors in girls than boys

This hypothesis was addressed by simple linear regression of pain scores on each predictor and these are shown in Table 3a, 3b, 3c and 3d in terms of unstandardised and standardised regression coefficients, t tests and p-values.

Table 3a

Simple Linear Regression: Headache

	Headache									
	R^2		Unstandardised β		95% CI		Standardised β		T (sig)	
Gender	B	G	B	G	B	G	B	G	B	G
Subjective Health	.013	.048	-.199	-.421	-.274, -.124	-.498, -.345	-.113	-.220	-5.196 (<.001)	-10.858 (<.001)
Aboriginal & Torres Strait Islander	.000	.004	-.088	.390	-.359, .184	.133, .648	-.014	.062	-.632 (.527)	2.974 (.003)
Support of Closest Friends	.001	.008	-.009	-.032	-.022, .003	-.046, -.017	-.031	-.088	-1.432 (.152)	-4.252 (<.001)
Conflict of Friends	.023	.015	.052	.050	.037, .086	.033, .066	.152	.122	7.001 (<.001)	5.933(<.001)
School Satisfaction	.054	.095	-.067	-.102	-.079, -.055	-.114, -.089	-.231	-.308	-10.825 (<.001)	-15.592 (<.001)
Bullying	.053	.091	.061	.081	.050, .072	.070, .091	.231	.301	10.832 (<.001)	15.252 (<.001)
Puberty	.000	.007	-.035	.173	-.116, .047	.083, .262	-.019	.081	-.837 (.403)	3.778 (<.001)
Menstruation		.000		-.019		-.092, .055		-.011		-.498 (.618)
SES Deprivation	.002	.015	-.514	-1.171	-.961, -.068	-1.566, -.776	-.050	-.120	-2.258 (.024)	-5.808 (<.001)
SEIFA	.000	.000	.020	-.027	-.045, .085	-.096, .042	.013	-.016	.599 (.549)	-.775 (.438)
Missed School	.020	.042	.247	.400	.170, .324	.318, .482	.142	.205	6.284(<.001)	9.563 (<.001)
School Pressure	.020	.052	.180	.317	.125, .235	.262, .372	.140	.228	6.445 (<.001)	11.295 (<.001)
Cantril Quality of Life	.049	.079	-.159	-.205	-.189, -.129	-.234, -.177	-.222	-.281	-10.566(<.001)	-14.129 (<.001)
Emotional State	.298	.337	.159	.168	.148, .169	.158, .177	.546	.581	29.733 (<.001)	34.389 (<.001)
Deprivation	.004	.016	.408	.952	.123, .693	.646, 1.257	.061	.126	2.806 (.005)	6.106 (<.001)
Life Satisfaction	.055	.102	-.067	-.091	-.079, -.055	-.102, -.080	-.235	-.319	-10.948 (<.001)	-16.082 (<.001)

Table 3b

Simple Linear Regression: Stomach-ache

	Stomach-ache									
	R^2		Unstandardised β		95% CI		Standardised β		T (sig)	
Gender	B	G	B	G	B	G	B	G	B	G
Subjective Health	.009	.046	-.150	-.363	-.217, -.083	-.430, -.295	-.096	-.214	-4.390 (<.001)	-10.505 (<.001)
Aboriginal & Torres Strait Islander	.001	.001	.127	.170	-.114, .368	-.062, .402	.023	.030	1.034 (.301)	1.440 (.150)
Support of Closest Friends	.000	.005	-.004	-.024	-.016, .007	-.037, -.011	-.015	-.074	-.704 (.481)	-3.553 (<.001)
Conflict of Friends	.040	.018	.061	.048	.048, .074	.034, .063	.201	.134	9.311 (.001)	6.499 (<.001)
School Satisfaction	.044	.074	-.054	-.080	-.065, -.043	-.091, -.068	-.210	-.273	-9.777 (<.001)	-13.581 (<.001)
Bullying	.064	.081	.059	.068	.049, .069	.059, .077	.252	.285	11.900 (<.001)	14.307 (<.001)
Puberty	.000	.002	-.032	.076	-.105, .040	-.005, .156	-.020	.040	-.878 (.380)	1.851 (.064)
Menstruation		.000		.000		-.065, .065		.000		.010 (.992)
SES Deprivation	.002	.013	-.445	-.988	-.843, - .046	-1.343, -.633	-.048	-.114	-2.190 (.029)	-5.451 (<.001)
SEIFA	.001	.000	-.034	-.004	-.092, .025	-.066, .057	-.025	-.003	-1.129 (.259)	-.143 (.886)
Missed School	.026	.043	.250	.359	.182, .319	2.85, .432	.162	.207	7.165 (<.001)	9.591 (<.001)
School Pressure	.022	.035	.171	.229	.122, .219	.179, .278	.149	.186	6.835 (<.001)	9.075 (<.001)
Cantril Quality of Life	.037	.063	-.124	-.162	-.152, - .097	-.187, -.136	-.193	-.251	-8.961 (<.001)	-12.450 (<.001)
Emotional State	.343	.297	.152	.140	.143, .161	.131, .148	.586	.545	32.948 (<.001)	31.270 (<.001)
Deprivation	.005	.013	.439	.774	.185, .693	.500, 1.048	.074	.115	3.387 (.001)	5.543 (<.001)
Life Satisfaction	.052	.082	-.057	-.072	-.068, -.047	-.082, -.062	-.229	-.286	-10.629(<.001)	-14.231(<.001)

Table 3c

Simple Linear Regression: Backache

	Backache									
	R^2		Unstandardised β		95% CI		Standardised β		T (sig)	
Gender	B	G	B	G	B	G	B	G	B	G
Subjective Health	.005	.029	-.131	-.329	-.209, -.053	-.406, -.251	-.072	-.171	-3.291 (.001)	-8.310 (<.001)
Aboriginal & Torres Strait Islander	.000	.001	.142	.209	-.140, .424	-.055, .472	.022	.032	.987 (.324)	1.554 (.120)
Support of Closest Friends	.000	.003	-.004	-.021	-.017, .009	-.036, -.007	-.013	-.059	-.576 (.564)	-2.835 (.005)
Conflict of Friends	.022	.016	.053	.052	.038, .068	.036, .069	.150	.128	6.873 (.000)	6.196 (<.001)
School Satisfaction	.055	.066	-.070	-.085	-.083, -.058	-.098, -.072	-.234	-.257	-10.963 (<.001)	-12.764 (<.001
Bullying	.057	.064	.065	.068	.054, .076	.058, .079	.238	.253	11.168 (<.001)	12.553 (<.001)
Puberty	.004	.005	.116	.157	.032, .200	.066, .249	.061	.073	2.714 (.007)	3.380 (.001)
Menstruation		.000		-.032		-.106, .042		-.018		-.841 (.401)
SES Deprivation	.003	.011	-.647	-1.035	-1.121, -.174	-1.445, -.625	-.059	-.103	-2.680 (.007)	-4.949 (<.001)
SEIFA	.000	.000	.026	-.031	-.042, .093	-.100, .039	.016	-.018	.744 (.457)	-.861 (.389)
Missed School	.019	.029	.250	.336	.170, .330	.252, .419	.138	.171	6.122 (<.001)	7.896 (<.001)
School Pressure	.022	.048	.200	.306	.143, .257	.251, .362	.150	.219	6.889 (<.001)	10.790 (<.001)
Cantril Quality of Life	.035	.050	-.139	-.165	-.170, -.107	-.194, -.136	-.186	-.224	-8.616 (<.001)	-11.062 (<.001
Emotional State	.279	.245	.160	.144	.148, .171	.134, .155	.528	.495	28.354 (<.001)	27.367 (<.001)
Deprivation	.002	.019	.275	1.060	-.022, .571	.750, 1.370	.040	.139	1.816 (.069)	6.712 (<.001)
Life Satisfaction	.038	.073	-.057	-.077	-.070, -.045	-.089, -.066	-.195	-.269	-8.98 (<.001)	-13.331 (<.001

Table 3d

Simple Linear Regression: Somatic Pain

	Somatic Score									
	R^2		Unstandardised β		95% CI		Standardised β		T (sig)	
Gender	B	G	B	G	B	G	B	G	B	G
Overall Subjective Health	.013	.059	-.482	-1.108	-.662, – .302	-1.288, -.928	-.114	-.234	-5.262 (<0.001)	-12.080 (<.001)
Aboriginal & Torres Strait Islander	.00	.003	.188	.859	-4.63, .838	.247, 1.472	.012	.057	.566 (.571)	2.753 (.006)
Support of Closest Friends	.001	.008	-.018	-.077	-.048, .013	-.112, -.042	-.025	-.090	-1.123 (.262)	-4.338 (<.001)
Conflict of Friends	.042	.024	.167	.149	.132, .201	.111, .188	.204	.155	9.504 (<.001)	7.569 (<.001)
School Satisfaction	.076	.115	-.190	-.265	-.219, -.162	-.295, -.235	-.276	-.339	-13.089 (<.001)	-17.365 (<.001)
Bullying	.087	.118	.187	.219	.161, .213	.194, .243	.295	.344	14.136 (<.001)	17.67 (<.001)
Puberty	.000	.007	.025	.413	-.168, .218	.200, .626	.006	.081	.253 (.800)	3.806 (<.001)
Menstruation		.000		-.061		-.236, .113		-.015		-.690 (.490)
SES Deprivation	.004	.021	-1.612	-3.337	-2.685, -.539	-4.275, -2.400	-.065	-.144	-2.946 (.003)	-6.980 (<.001)
SEIFA	.000	.000	.000	-.058	-.157, .157	-.221, .105	.000	-.014	.001 (1.00)	-.695 (.487)
Missed School	.034	.057	.771	1.105	.588, .954	.912, 1.298	.185	.239	8.261 (<.001)	11.232 (<.001)
School Pressure	.031	.066	.542	.848	.411, .673	.718, .978	.175	.257	8.129 (<.001)	12.795 (<.001)
Cantril Quality of Life	.061	.092	-.425	-.526	-.497, -.353	-.593, -.459	-.247	-.303	-11.625 (<.001)	-15.347 (<.001)
Emotional State	.458	.434	.472	.451	.450, 4.94	.430, 4.72	.677	.659	42.023 (<.001)	42.215 (<.001)
Deprivation	.005	.025	1.085	2.821	.400, 1.770	2.098, 3.545	.068	.157	3.107 (.002)	7.645 (<.001)
Life Satisfaction	.073	.127	-.183	-.241	-.211, -.154	-.267, -.215	-.270	-.356	-12.716 (<.001)	-18.229 (<.001)

Hypothesis 1b is partially supported by univariate correlates associated with somatic pain. The independent predictor that was most strongly associated with somatic pain was emotional state in both boys (β = .677, $p < .001$) and girls (β = .659, $p < .001$). Emotional state had the strongest associations across headaches for boys (β = .546, p < .001) and girls (β = .581, p < .001), stomach-ache for boys (β = .586, $p < .001$) and girls (β = .545, p < .001) and backache for boys (β = .528, p < .001) and girls (β = .495, p < .001).

Social measures such as bullying are moderately associated with somatic pain in boys (β = .295, p < .001) and girls (β = .344, p < .001). This is similar across headache in boys (β = .231, p < .001) and girls (β = .301, p < .001), stomach-ache for boys (β = .252, p < .001) and girls (β = .285, p < .001) and backache for boys (β = .238, p < .001) and girls (β = .253, p < .001). Similarly, there was a moderate association between cantril quality of life and somatic pain in boys (β = - .247, p < .001) and girls (β = - .303, p < .001) which is common in headaches for boys (β = - .222, p < .001) and girls (β = - .281, p < .001), stomach-ache for boys (β = - .193, p < .001) and girls (β = - .251, p < .001) and backache for boys (β = - .186, p < .001) and girls (β = - .224, p < .001).

Furthermore, social variables associated with school life such as missed school last term is weakly associated with somatic pain in boys (β = .185, p < .001) and girls (β = .239, p < .001), headache in boys (β = .142, p < .001) and girls (β = .205, p < .001), stomach-ache in boys (β = .162, p < .001) and girls (β = .207, p < .001) and backache in boys (β = .138, p < .001) and girls (β = .171, p < .001). School satisfaction for boys (β = -.276, p < .001) and girls (β = -.339, p < .001) was moderately associated with somatic pain, headache for boys (β = -.231, p < .001) and girls (β = - .308, p < .001), stomach-ache for boys (β = - .210, p < .001) and girls (β = - .273, p < .001) and backache in boys (β = -.234, p < .001) and girls (β = - .257, p < .001)

There were differences between boys and girls in the association between puberty and somatic pain in girls (β = .081, p < .001) where as boys were (β = .006, p = .800). This is similar in headaches for boys (β = - .019, p = .403) and girls (β = .081, p < .001), stomach-ache for boys (β = - .020, p = .380) and girls (β = .040, p = .064). However, for backache there was no significant difference between gender as for boys (β = .061, p = .007) and girls (β = .073, p = .001). Therefore, hypothesis 1b is partially supported for girls who have higher pubertal development scores experiencing higher levels of somatic pain, headache and stomach-ache but not for backache. Other univariate associations between variables and outcomes of somatic pain are not statistically significant different between boys and girls.

3.4 Results for Aim Two. The purpose is to identify the potential predictors independently and additively that predict the level of somatic burden for both boys and girls.

Aim 2 was addressed through multiple linear regression as shown in Table 4 to explore which predictor variables are independently or additively predictive of somatic pains. Measures of standardised β coefficient, squared part correlations and bootstrapped p-values were analysed to establish the size of effect.

Table 4a

Multiple Linear Regression: Headache

Headache													
Boys							Girls						
IV's	R^2	β	95% CI	Standardised β	T (Bootstrap sig)[a]	Squared Part Correlation	**IV's**	R^2	β	95% CI	Standardised β	T (Bootstrap sig)[a]	Squared Part Correlation
Support of Friends		.009	-.003, .021	.030	1.522 (.143)	.001	**School Satisfaction**		-.017	-.029, -.004	-.050	-2.511 (.008)	.088
School Satisfaction		-.020	-.032, -.008	-.068	-3.326 (.002)	.004	**SES Deprivation**		-.443	-.896, -.034	-.043	-2.434 (.038)	.086
	.302							.363					
Missed School		.098	.020, .179	.056	2.886 (.016)	.003	**Missed School**		.123	.047, .195	.062	3.371 (.001)	.004
Emotional State		.150	.136, .163	.516	25.446 (<.001)	.238	**Emotional State**		.160	.149, .173	.555	28.035 (<.001)	.246

Note. a Bootstrapped significance of the model fit after backward elimination

Table 4b

Multiple Linear Regression: Stomach-ache

Stomach-ache												
			Boys						Girls			
IV's	R^2	β	95% CI	Standardised β	T (Bootstrap sig)[a]	Squared Part Correlation	**IV's**	R^2	β	95% CI	Standardised β	T (Bootstrap sig)[a]	Squared Part Correlation
Support of Friends		.010	-.001, .021	.036	1.932 (.067)	.001	**Overall Subjective Health**		.058	-.127, .007	-.034	-1.779 (.095)	.066
Conflict of Friends		.015	.003, .027	.049	2.555 (.016)	.002	**Bullying**	.313	.017	.006 ,-.029	.072	3.576 (.004)	.004
SEIFA		-.059	-.106, -.009	.044	-2.361 (.016)	.001	**Missed School**		.144	.073, .210	.082	4.344 (<.001)	.006
Missed School	.356	.117	.050, .181	.075	4.001 (.001)	.005	**Emotional State**		.125	.113, .137	.489	23.304 (<.001)	.181
Cantril Quality of Life		.028	-.003, .058	- .042	1.931 (.076)	.001							
Emotional State		.148	.136, .160	.575	27.594 (<.001)	.264							
Life Satisfaction		-.004	-.016, .008	-.015	-.624 (.533)	.001							

Note. a Bootstrapped significance of the model fit after backward elimination

Table 4c

Multiple Linear Regression: Backache

Backache												
Boys							Girls					
IV's	R^2	β	95% CI	Standardised β	T (Bootstrap sig)[a]	Squared Part Correlation	**IV's**	R^2	β	95% CI	Standardised β	T (Bootstrap sig)[a]	Squared Part Correlation
School Satisfaction		-.020	-.034, -.006	-.068	-3.207 (.003)	.004	**Support of Friends**		.014	.000, .029	.040	2.065 (.042)	.002
Missed School		.114	.039, .188	.063	3.078 (.005)	.004	**Bullying**		.012	.000, .025	.046	2.148 (.050)	.002
Deprivation	.272	-.339	-.621, -.058	-.049	-2.424 (.020)	.002	**Missed School**	.251	.117	.037, .200	.060	3.034 (.009)	.003
Emotional State		.146	129, .163	.484	22.548 (<.001)	.202	**School Pressure**		.099	.042, .158	.072	3.522 (.001)	.004
Puberty		.091	.021 , .163	.048	2.383 (.010)	.002	**Emotional State**		.127	.111, .142	.437	19.341 (<.001)	.137

Note. a Bootstrapped significance of the model fit after backward elimination

Table 4d

Multiple Linear Regression: Somatic Pain

Somatic Pain												
	Boys						Girls					
IV's	R^2	β	95% CI	Standardised β	T (Bootstrap sig)[a]	Squared Part Correlation	**IV's**	R^2	β	95% CI	Standardised β	T (Bootstrap sig)[a]	Squared Part Correlation
Support of Friends		.027	.001, .054	.037	2.164 (.038)	.0013	**Overall Subjective Health**		-.117	-.277, .044	-.026	-1.491 (.168)	.048
School Satisfaction		-.046	-.072, -.018	-.067	-3.701 (.001)	.0038	**Support of Friends**		.023	-.006, .054	.027	1.607 (.120)	.001
Emotional State	.463	.449	.421, .477	.651	36.144 (<.001)	.368	**Bullying**		.044	.019, .069	.069	3.773 (.001)	.004
Deprivation		-.672	-1.286, -.025	-.042	-2.465 (.029)	.0017	**SES Deprivation**	.457	-1.046	-2.024, .019	-.044	-2.654 (.037)	.086
Missed School		.301	.142, .469	.072	4.230 (.001)	0.005	**Missed School**		.375	.210, .542	.080	2.650 (<.001)	.006
							School Pressure		.152	.039, .270	.046	2.650 (.014)	.002
							Emotional State		.405	.375, .436	.591	29.900 (<.001)	.240

Note. a Bootstrapped significance of the model fit after backward elimination

Aim 2 identified important biological, psychological and social predictors independently and additively that predict the frequency of somatic pain for both boys and girls. Emotional state has a statistically significant relationship with somatic pain for boys (β = .651, bootstrapped p <.001) and girls (β = .591, bootstrapped p <.001) and accounts for 37% and 24% of the variance in for both boys and girls respectively shown in Table 4d. Other independent predictors of somatic pain in boys and girls were school satisfaction (β = -.067, bootstrapped p = .001) and missed school (β = .072, bootstrapped p = .001). However, girls have different predictors associated with somatic pain including bullying (β = .069, bootstrapped p = .001) and missed school (β = .080, bootstrapped p <.001). After backward elimination, girls had a larger number of predictors associated with somatic pain including overall subjective health, socioeconomic deprivation and school pressure than boys.

Only a small subset of variables remained statistically significant after backward elimination. The strongest independent predictor of headache frequency was emotional state which is similar between boys (β = .516, bootstrapped p <.001) and girls (β = .555, bootstrapped p <.001). Emotional state accounted for 24% and 25% of the variance in headaches, for boys and girls respectively as shown in Table 4a. However, there were some differences between boys and girls in the predictors associated with headache after backward elimination. For boys, there were stronger associations for support of friends (β = .030, bootstrapped p = .143) and for girls' socioeconomic deprivation was associated with headaches (β = - .043, bootstrapped p = .038) and missed school (β = .062, bootstrapped p = .001).

Predictive factors of stomach-ache were most strongly associated with emotional state for both boys (β = .575, bootstrapped p <.001) and girls (β = .489, bootstrapped p < .001) which is similar across all the somatic pains. For adolescents with stomach-ache, emotional state

accounted for 26% and 18% of the variance in boys and girls respectively. Also strongly associated with stomach-ache was missed school in both boys (β = .075, bootstrapped p = .001) and girls (β = .082, bootstrapped p = < .001). However, the biggest difference between stomach-ache and the other somatic pains is the presence of the cantril quality of life (β = -.042, bootstrapped p = .076) and life satisfaction (β = -.015, bootstrapped p = .533) shown in Table 4b. However, for girls, missed school (β = .082, bootstrapped p <.001) and bullying (β = .072, bootstrapped p = .004) were weak predictors of stomach-ache.

The strongest predictor for backache was emotional state in both boys (β = .484, bootstrapped p <.001) and girls (β = .437, bootstrapped p <.001), which is the most consistent predictor across all somatic pains. Emotional state accounts for over 20% and 14% of the variance in backache for boys and girls respectively shown in Table 4c. in girls shown in table 4c. For boys, variables such as school satisfaction (β = -.068, bootstrapped p = .003) and puberty (β = .048, bootstrapped p = .010) were both associated with backache after backward elimination. However, for girls variables such as school pressure (β = .072, bootstrapped p = .001), bullying (β = .046, bootstrapped p = .050) and support of friends (β = .040, bootstrapped p = .042) were more significant predictors of backache.

In summary, emotional state was the strongest predictor of all somatic pains types and accounts for the largest amount of variance. For headache there was a significant association between support of friends in boys and socioeconomic deprivation in girls. However, for stomach-ache there was a stronger association between quality of life measures for both boys and girls. Puberty was only seen to be a significant predictor for backache in boys, whereas for girls school pressure was strongly associated with backache. Overall somatic pain placed a larger burden on boys and girls and this was associated with psychological and social factors.

3.5 Results for Aim Three. To investigate whether the association between emotional state and somatic pain disorders are moderated by social predictors and pubertal development for boys and girls

This aim is explored through moderation analyses as shown in Table 5 to explore whether social environment and pubertal development have a moderating effect on the relationship between emotional state and somatic pain. Measures of β standard coefficient are used to establish the size of effect.

Table 5a

Moderation Analysis of Headache

	Moderation of Headache and Emotional State											
	Boys						Girls					
Hypothesis	R^2	β	95% CI	Standardised β	T (sig)	Squared Part Correlation	R^2	β	95% CI	Standardised β	T (sig)	Squared Part Correlation
Support of Friends	.295	.003	.001, .006	.183	2.518 (.012)	.002	.339	-.002	-.004, .001	-.099	-1.321 (.187)	.044
Conflict of Friends	.295	.000	-.002, .003	.010	.172 (.863)	.000	.337	.001	-.002, .003	.026	.444 (.657)	.000
Bullying	.300	.002	.000, .004	.136	2.152 (.032)	.002	.341	-.001	-.002, .001	-.049	-.744 (.457)	.026
Missed School	.302	-.003	-.016, .009	-.032	-.489 (.625)	.018	.354	-.006	-.019, .007	-.059	-.854 (.393)	.000
School Satisfaction	.298	-.001	-.003, .001	-.049	-.753 (.451)	.028	.345	-.001	-.003, .002	-.029	-.475 (.635)	.016
Puberty	.292	-.001	-.016, .014	-.008	-.104 (.917)	.004	.335	-.013	-.029, .003	-.145	-1.555 (.120)	.054
Deprivation	.297	-.015	-.071, .041	-.024	-.513 (.608)	.018	.338	.043	-.009, .095	.075	1.626 (.104)	.000
SES Deprivation	.295	-.080	-.164, .004	-.035	-1.876 (.061)	.070	.343	.049	-.022, .120	.172	1.342 (.180)	.001

Note. R^2 calculated from total model. All other statistics based off interaction term.

Table 5b

Moderation Analysis of Stomach-ache

	Moderation of Stomach-ache and Emotional State											
	Boys						Girls					
Hypothesis	R^2	β	95% CI	Standardised β	T (sig)	Squared Part Correlation	R^2	β	95% CI	Standardised β	T (sig)	Squared Part Correlation
Support of Friends	.339	.000	-.002, .002	-.011	-.157 (.875)	.006	.300	.000	-.002, .003	.025	.325 (.745)	.000
Conflict of Friends	.345	.002	.000, .004	.116	2.026 (.043)	.001	.298	.001	-.002, .003	.027	.439 (.661)	.000
Bullying	.345	.002	.000, .003	.139	2.273 (.023)	.002	.302	.001	.000, .003	.110	1.624 (.105)	.001
Missed School	.353	.015	.004, .025	.168	2.687 (.007)	.002	.310	.013	.001, .025	.152	2.106 (.035)	.002
School Satisfaction	.339	-.002	-.004, .000	-.127	-2.037 (.042)	.072	.302	.000	-.002, .002	.007	.112 (.911)	.000
Puberty	.341	-.018	-.031, -.005	-.206	-2.757 (.006)	.100	.290	-.030	-.045, -.015	-.372	-3.853 (.000)	.140
Deprivation	.342	-.012	-.060, .036	-.023	-.487 (.626)	.018	.298	-.013	-.061, .035	-.025	-.531 (.595)	.018
SES Deprivation	.335	-.025	-.098, .048	-.098	-.677 (.498)	.024	.300	-.032	-.097, .033	-.127	-.961 (.337)	.034

Note. R^2 calculated from total model. All other statistics based off interaction term.

Table 5c

Moderation Analysis of Backache

	Moderation of Backache and Emotional State											
	Boys						Girls					
Hypothesis	R^2	β	95% CI	Standardised β	T (sig)	Squared Part Correlation	R^2	β	95% CI	Standardised β	T (sig)	Squared Par Correlation
Support of Friends	.277	.002	-.001, .004	.094	1.272 (.204)	.001	.245	-.002	-.005, .000	-.151	-1.888 (.059)	.068
Conflict of Friends	.275	.000	-.002, .003	.015	.257 (.797)	.000	.243	.002	-.001, .005	.068	1.083 (.279)	.000
Bullying	.280	.001	-.001, .003	.048	.750 (.454)	.000	.247	.001	-.001, .003	.083	1.181 (.238)	.000
Missed School	.280	.009	-.005, .022	.084	1.273 (.203)	.001	.244	.011	-.003, .026	.116	1.537 (.124)	.001
School Satisfaction	.284	-.003	-.006, -.001	-.176	-2.702 (.007)	.10	.246	.000	-.002, .003	.012	.176 (.860)	.000
Puberty	.267	-.004	-.020, .012	-.039	-.486 (.627)	.018	.236	-.012	-.030, .005	-.136	-1.362 (.173)	.052
Deprivation	.279	-.019	-.078, .040	-.030	-.623 (.533)	.024	.245	.005	-.051, .061	.009	.176 (.860)	.000
SES Deprivation	.272	-.092	-.184, -.001	-.309	-1.975 (.048)	.074	.248	-.037	-.114, .041	-.129	-.928 (.353)	.034

Note. R^2 calculated from total model. All other statistics based off interaction term.

Table 5d

Moderation Analysis of Somatic Pain

	Moderation of Somatic Pain and Emotional State											
	Boys						Girls					
Hypothesis	R^2	β	95% CI	Standardised β	T (sig)	Squared Part Correlation	R^2	β	95% CI	Standardised β	T (sig)	Squared Part Correlation
Support of Friends	.452	.006	.000, .011	.134	2.106 (.035)	.001	.435	-.004	-.009, .001	-.099	-1.434 (.152)	.044
Conflict of Friends	.451	.002	-.003, .008	.046	.874 (.382)	.000	.433	.003	-.003, .009	.053	.971 (.332)	.000
Bullying	.460	.005	.001, .009	.129	2.328 (.020)	.001	.439	.002	-.002, .005	.046	.764 (.445)	.000
Missed School	.465	.022	-.004, .048	.094	1.653 (.098)	.001	.445	.019	-.010, .048	.082	1.275 (.202)	.000
School Satisfaction	.456	-.006	-.011, -.001	-.138	-2.443 (.015)	.08	.439	.000	-.005, .005	-.002	-.040 (.968)	.002
Puberty	.449	-.030	-.061, .002	-.124	-1.839 (.066)	.06	.425	-.055	-.092, -.019	-.261	-3.017 (.003)	.098
Deprivation	.458	-.063	-.180, .055	-.044	-1.045 (.296)	.034	.433	.032	-.082, .147	.023	.551 (.582)	.000
SES Deprivation	.452	-.185	-.362, -.007	-.270	-2.042 (.041)	.066	.439	-.026	-.182, .130	-.039	-.329 (.742)	.010

Note. R^2 calculated from total model. All other statistics based off interaction term.

Hypothesis 3a. Negative emotional state will more strongly, positively predict somatic pain for adolescents with a worse relationship with peers (greater support of friends, greater conflict with friends and greater levels of bullying)

Hypothesis 3a was partially supported across somatic pain types, however there are differences between boys and girls. The relationship between somatic pain and negative emotional state is moderated by the support of closest friends (standardised $\beta = .134$, $p = .035$) and bullying (standardised $\beta = .129$, $p = .020$) for boys. However, for girls there was no clear moderating effect between conflict or support of friends, or bullying. This was similar for the relationship between negative emotional state and headache moderated by support of closest friends (standardised $\beta = .183$, $p = .012$) and bullying (standardised $\beta = .136$, $p = .032$) in boys. However, no significant moderators were identified in girls. The relationship between negative emotional state and stomach-ache was moderated by conflict of friends (standardised $\beta = .116$, $p = .043$) and bullying (standardised $\beta = .139$, $p = .023$) in boys. However, no significant moderator was identified in girls. There were no moderators of the relationship between negative emotional state and backache in boys however for girls support of friends (standardised $\beta = -.151$, $p = .059$) had a significant moderating effect. In summary, hypothesis 3a is partially supported for the moderating effects of support of closest friends and bullying on the relationship between negative emotional state and somatic pain, headache, stomach-ache for boys. However, for girls there was only a weak moderating effect of support of closest friends on the relationship between negative emotional state and backache.

Hypothesis 3b. Negative emotional state will more strongly, positively predict somatic pain for adolescents with greater missed school and less school satisfaction

Hypothesis 3b is partially supported for the moderating effects of school based variables (missed school and school satisfaction) on the relationship between negative emotional state and somatic pain. The relationship between negative emotional state and somatic pains was moderated by school satisfaction (standardised β = -.138, p = .015) in boys, however there was no significant moderator for girls. The relationship between negative emotional state and headache is not moderated by school based variables for boys or girls. However, the relationship between negative emotional state and stomach-ache was moderated by missed school (standardised β = .168, p = .007) and school satisfaction (standardised β = -.127, p = .042) in boys. This was similar for missed school (standardised β = .152, p = .035) in girls, however there was no moderating effect for school satisfaction. For boys the relationship between negative emotional state and backache was moderated by school satisfaction (standardised β = -.176, p = .007) however there was no significant moderator of the relationship between negative emotional state and backache in girls. In summary there are moderate moderating effects of missed school and school satisfaction on the relationship between somatic pain, stomach-ache and backache for boys. However, for girls there were moderating effects of missed school in the relationship between stomach-ache and emotional state but not for any other somatic pain type.

Hypothesis 3c. Negative emotional state will more strongly, positively predict somatic pain for girls with greater pubertal development stage compared to boys.

Hypothesis 3c is not supported with puberty being a strong negative moderator of the relationship between negative emotional state and somatic pains for girls (standardised β = -.261, p = .003), however for boys there was a reasonable size of effect but this is not statistically significant (standardised β = -.124, p = .066). There are no moderating effects of puberty on the relationship between negative emotional state and stomach-ache for either

boys or girls. However, there was a strong negative moderating effect of puberty on the relationship between negative emotional state and stomach-ache for girls (standardised β = -.372, p < .000) as well as boys (standardised β = -.206, p = .006). The same is not seen for the relationship between negative emotional state and backache for both boys and girls. In summary there was a strong negative moderating effect of puberty on the relationship between negative emotional state and somatic pain as well as stomach-ache for girls. However, puberty has a weaker moderating effect on the relationship between negative emotional state and somatic pain in boys.

Hypothesis 3d. Negative emotional state will more strongly, positively predict somatic pains for adolescents with greater material deprivation and lower SES status

Hypothesis 3d was not strongly supported for moderating effects across somatic pains, however there are some minor differences between genders. Socioeconomic deprivation was a strong negative moderator on the relationship between negative emotional state and somatic pain (standardised β = -.270, p = .041) for boys shown in Table 5d. However, there were no moderating effects for girls. There are no significant moderating effects of socioeconomic or material deprivation on the relationship between negative emotional state and headache and stomach-ache for boys or girls. There were strong negative moderating effects of socioeconomic deprivation on the relationship between negative emotional state and backache for boys (standardised β = -.309, p = .048) but no moderating effect for girls. In summary hypothesis 3d is not fully supported due to only two weak moderating effects of socioeconomic deprivation on the relationship between negative emotional state and somatic pain and backache for boys only and the possibility of statistical type I error given the number of moderation analyses conducted evaluating this hypothesis.

3.6 Results for Aim Four. To investigate the direct and indirect effects of psychosocial and pubertal development predictors on the relationship between emotional state and somatic pains for both boys and girls

Aim four extends on from aim two through path analysis as shown in Table 6 measuring the direct and indirect relationships between adolescent, school and social variables and individual somatic pain measures. Factors were included based from hypothesis 1c from multiple linear regression and backward elimination. We measured the direct and indirect effects in the relationship pathway between factors, emotional state and somatic pain in adolescents. Measures of the standardised path coefficients, bootstrapped standard errors and p-values of both the direct and indirect paths through emotional state to explore the strength of association to somatic pains.

Aim 4a. Among the psychosocial variables found to be statistically independently associated with headache, we aim to measure associations directly and indirectly through emotional state.

The results of two separate path analysis for aim 4a as illustrated in Figure 2a and 2b are shown as standardised path co-efficients, bootstrapped standard errors and p-values in Table 6a. For both boys and girls there is a strong direct association between emotional state and headache when even controlling for (psychosocial factors). The profile of fit statistics was reasonable but imperfect fit of the model to the data with some indices meeting specific criteria but other not. It shows there was a unique substantial relationship between emotional state and headache not accounted for by the other factors. This to be expected, as emotional state was the strongest predictor of headache being the strongest of all the psychosocial factors seen in aim 2. The relationship between school satisfaction and headache was significantly accounted by emotional state (β = -.149, SE=.015) for boys. For girls this

indirect relationship of school satisfaction was more significantly accounted for by emotional state (β = -.221, SE=.015). However, for missed school both genders operate evenly through both a direct and indirect path in their association with headache. Therefore, aim 4a is supported showing that school satisfaction operates through indirect pathways through emotional state for headache across both genders.

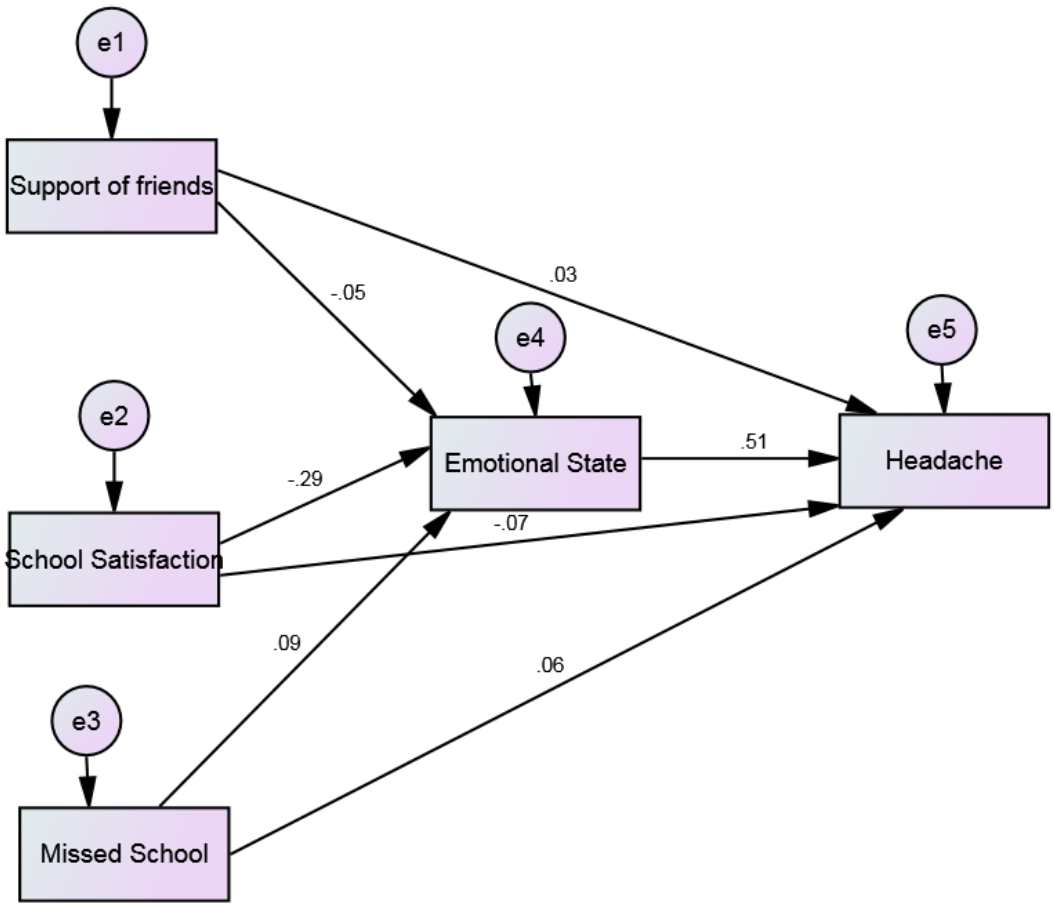


Figure 2a. Path Model: Boys Headache. $\chi^2(12) = 102.654$, p <.001, CMIN/df= 34.218. CFI= .900, RMSEA= .132

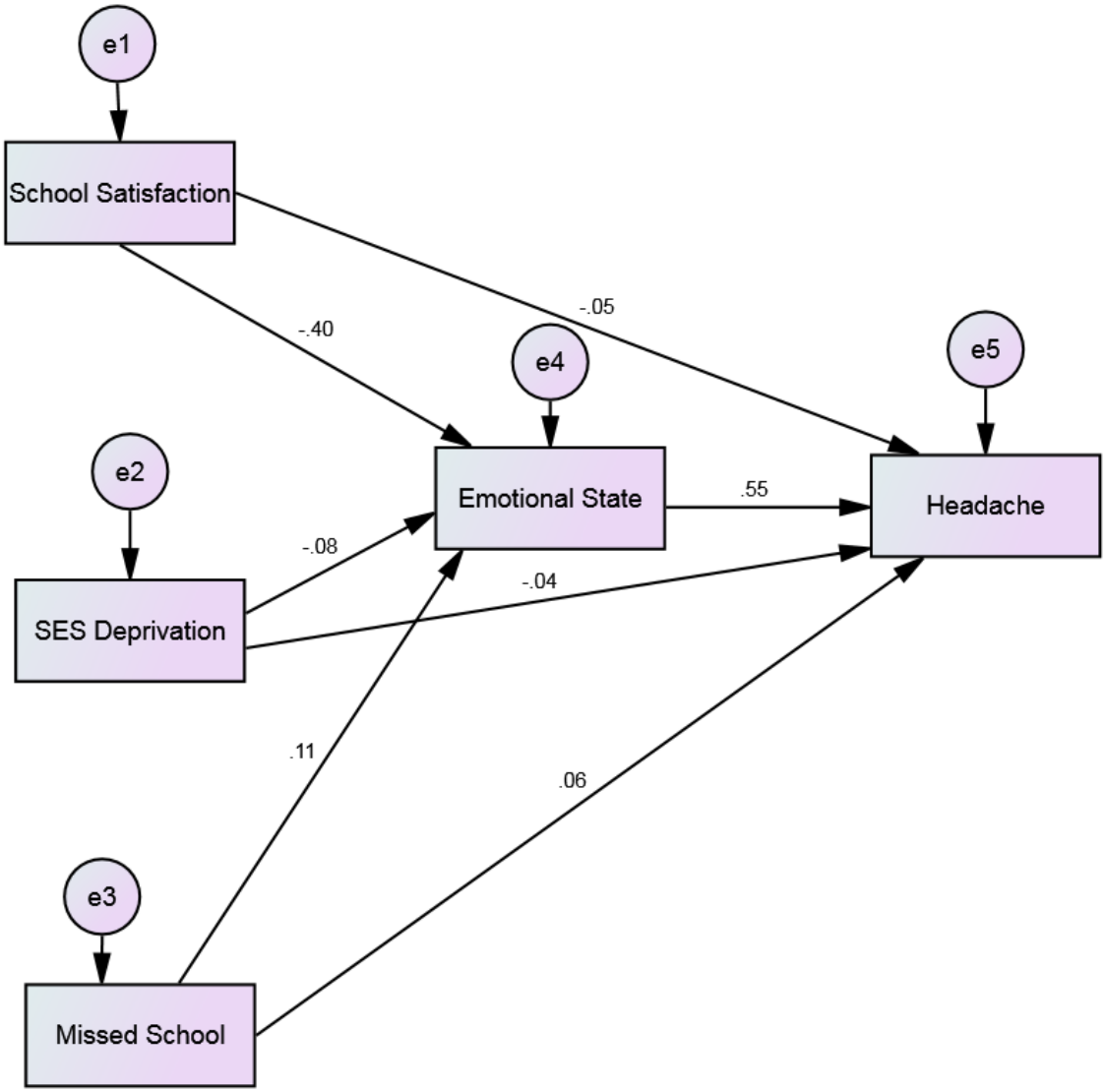


Figure 2b. Path Model: Girls Headache. $\chi^2(12) = 168.421$, $p < .001$, CMIN/df= 56.140. CFI= .892, RMSEA= .164

Table 6a

Path Model Headache

Headache and Emotional State							
	Boys (N=1905)				Girls (N=2039)		
IV's	Direct (SE)	Indirect (SE)	Total (SE)	**IV's**	Direct (SE)	Indirect (SE)	Total (SE)
Support of Friends	.030 (.020)	-.026 (.013)*	.003 (.024)	**School Satisfaction**	-.051 (.020)*	-.221 (.014)***	-.271 (.022)***
School Satisfaction	-.069 (.023)**	-.149 (.015)***	-.217 (.026)***	**SES Deprivation**	-.044 (.021)**	-.044 (.014)**	-.088 (.024)***
Missed School	.056 (.023)*	.048 (.015)**	.104 (.028)***	**Missed School**	.063 (.020)**	.060 (.013)***	.124 (.024)***
Emotional State	.514 (.022)***		.514 (.022)***	**Emotional State**	.553 (.019)***		.553 (.019)***

Note. * $p < .05$ ** $p < .01$ *** $p < .001$

Aim 4b. Among the psychosocial variables found to be statistically independently associated with stomach-ache, we aim to measure associations directly and indirectly through emotional state.

The results of the two separate path analysis for aim 4b as illustrated in Figure 3a and 3b are shown as results of the standardised path coefficients, bootstrapped standard errors and p-values in Table 6b. The profile of fit statistics was reasonable but imperfect fit of the model to the data with some indices meeting specific criteria but other not. For both boys and girls there was a strong direct association between emotional state and stomach-ache when even controlling for (psychosocial factors), which is showing that there was unique substantial relationship between emotional state and stomach-ache not accounted for by the other factors. For boys the relationship between Cantril quality of life and stomach-ache was largely accountable by emotional state (β = -.108, SE=.019) compared to the direct relationship (β = .039, *SE*=.026). Similarly, both conflict of friends (β = .100, SE=.014) and life satisfaction (β = -.140, SE=.020) operate indirectly through emotional state for boys. This is in contract to girls where the variables which operate indirectly through emotional state are overall subjective health (β = -.101, SE=.011) and bullying (β = .182, SE=.013). For both boys and girls missed school operates evenly through both direct and indirect paths in their association with stomach-ache. Therefore, aim 4b is supported investigating that psychosocial variables highlighted in aim 2 largely operate through an indirect pathway with emotional state in their association with stomach-ache which is different for both boys and girls.

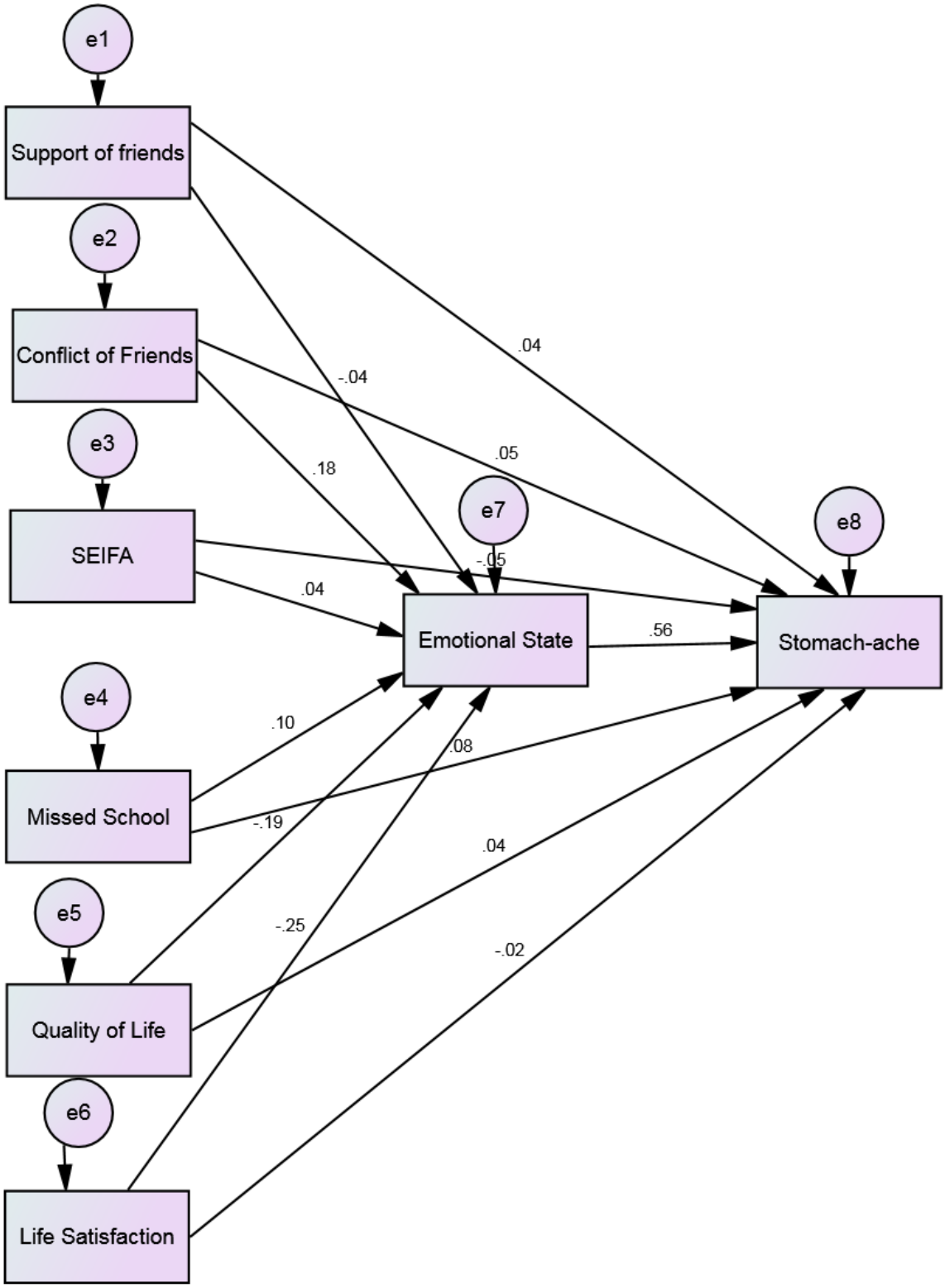


Figure 3a. Path Model: Boys Stomach-ache $\chi^2(21) = 964.848$, p <.001, CMIN/df= 64.323. CFI= .573, RMSEA= .184

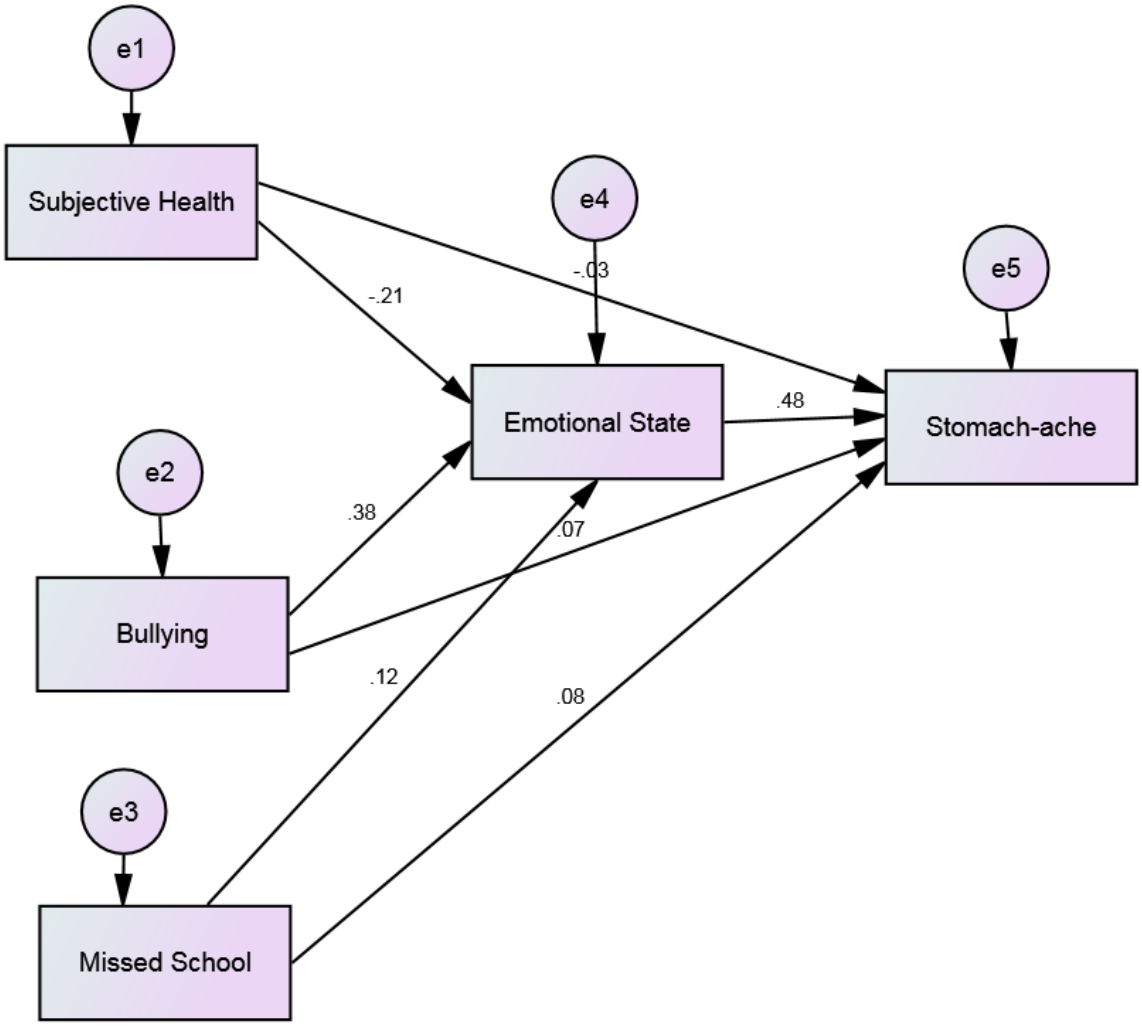


Figure 3b. Path Model: Girls Stomach-ache $\chi^2(12) = 177.626$, $p < .001$, CMIN/df= 59.209. CFI= .884, RMSEA= .168

Table 6b

Path Model Stomach-ache

	Stomachache and Emotional State						
	Boys (N=1867)				Girls (N=2061)		
IV's	Direct (SE)	Indirect (SE)	Total (SE)	**IV's**	Direct (SE)	Indirect (SE)	Total (SE)
Support of Friends	.036 (.020)	-.024 (.014)*	.012 (.025)	**Overall Subjective Health**	-.035 (.020)	-.101 (.011)***	-.136 (.022)***
Conflict of Friends	.049 (.022)*	.100 (.014)***	.149 (.027)***	**Bullying**	.074 (.024)**	.182 (.013)***	.255 (.026)***
SEIFA	-.046 (.019)*	.020 (.011)	-.026 (.022)	**Missed School**	.084 (.022)***	.060 (.012)***	.144 (.025)***
Missed School	.077 (.022)***	.054 (.016)***	.131 (.030)***	**Emotional State**	.484 (.022)***		.484 (.022)***
Cantril Quality of Life	.039 (.026)	-.108 (.019)***	-.069 (.034)***				
Life Satisfaction	-.015 (.027)	-.140 (.020)***	-.155 (.033)***				
Emotional State	.558 (.023)***		.558 (.023)***				

Note. * $p < .05$ ** $p < .01$ *** $p < .001$

Aim 4c. Among the psychosocial and pubertal development variables found to be statistically independently associated with backache, we aim to measure associations directly and indirectly through emotional state.

The results of the two separate path analysis for aim 4c as illustrated in Figure 4a and 4b shown as results of the standardised path coefficients, bootstrapped standard errors and p-values in Table 6c. The profile of fit statistics was reasonable but imperfect fit of the model to the data with some indices meeting specific criteria but other not. For both boys and girls there was a strong direct association between emotional state and backache when even controlling for (psychosocial factors), which showed that there was a unique substantial relationship between emotional state and backache not accounted for by the other factors. For boys the relationship between deprivation and backache operates indirectly through emotional state (β = .074, SE=.012) however also operates directly through a negative relationship (β = -.049, SE=.021). Similarly, the relationship between school satisfaction operates indirectly through emotional state (β = -.142, SE=.014). However, the relationship between Boys puberty and backache operates directly without emotional state (β = .048, SE=.020). For girls the relationship between bullying and backache operate indirectly through emotional state (β = .155, SE=.013). For both boys and girls, missed school operates evenly through both direct and indirect paths in their association with backache. Therefore, aim 4c is supported highlighting the psychosocial and pubertal developmental variables from aim 2 operate through both direct and indirect pathways with emotional state which is different between genders.

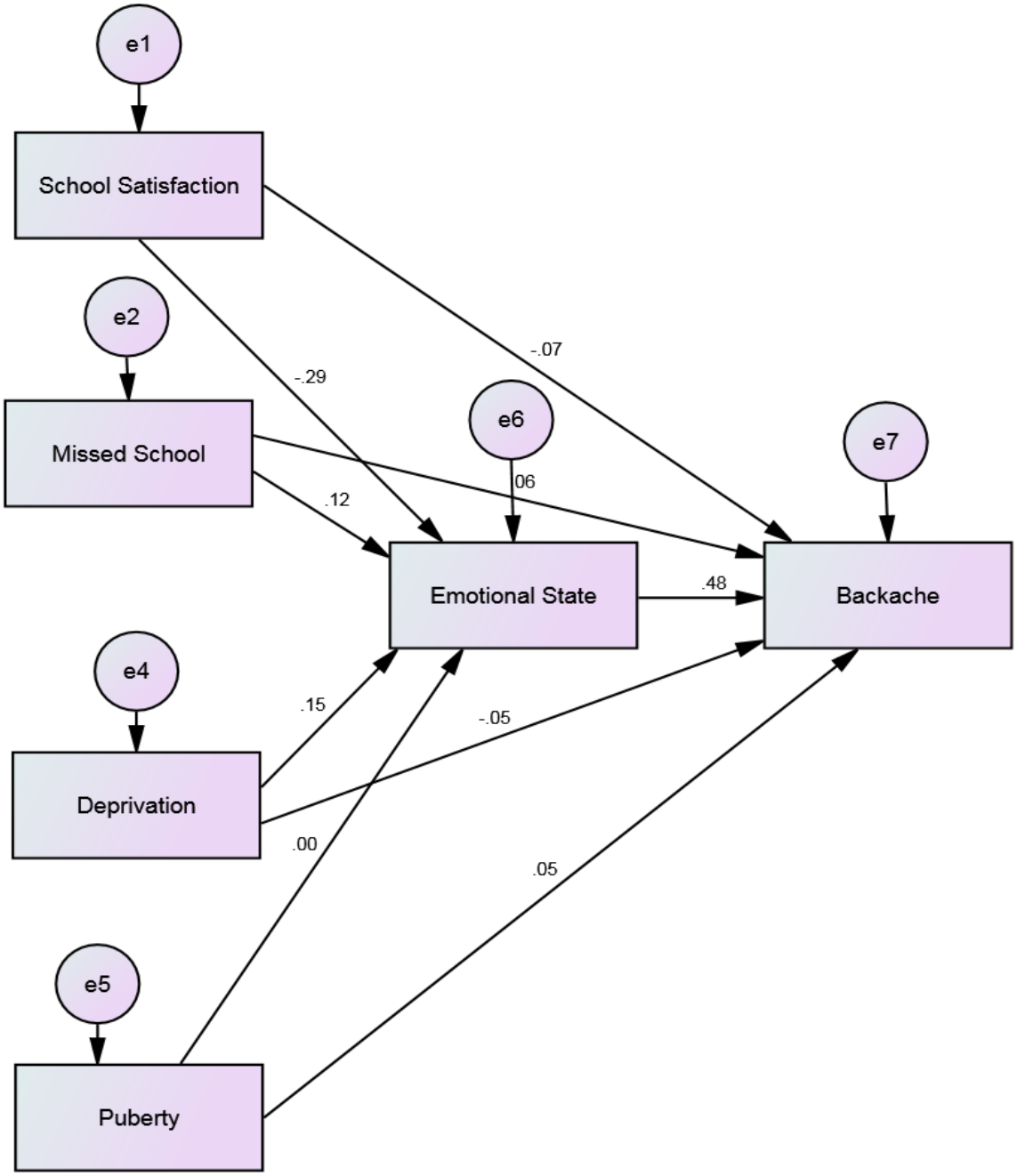


Figure 4a. Path Model: Boys Backache $\chi^2(15) = 80.721$, $p < .001$, CMIN/df= 13.454. CFI= .919, RMSEA= .082

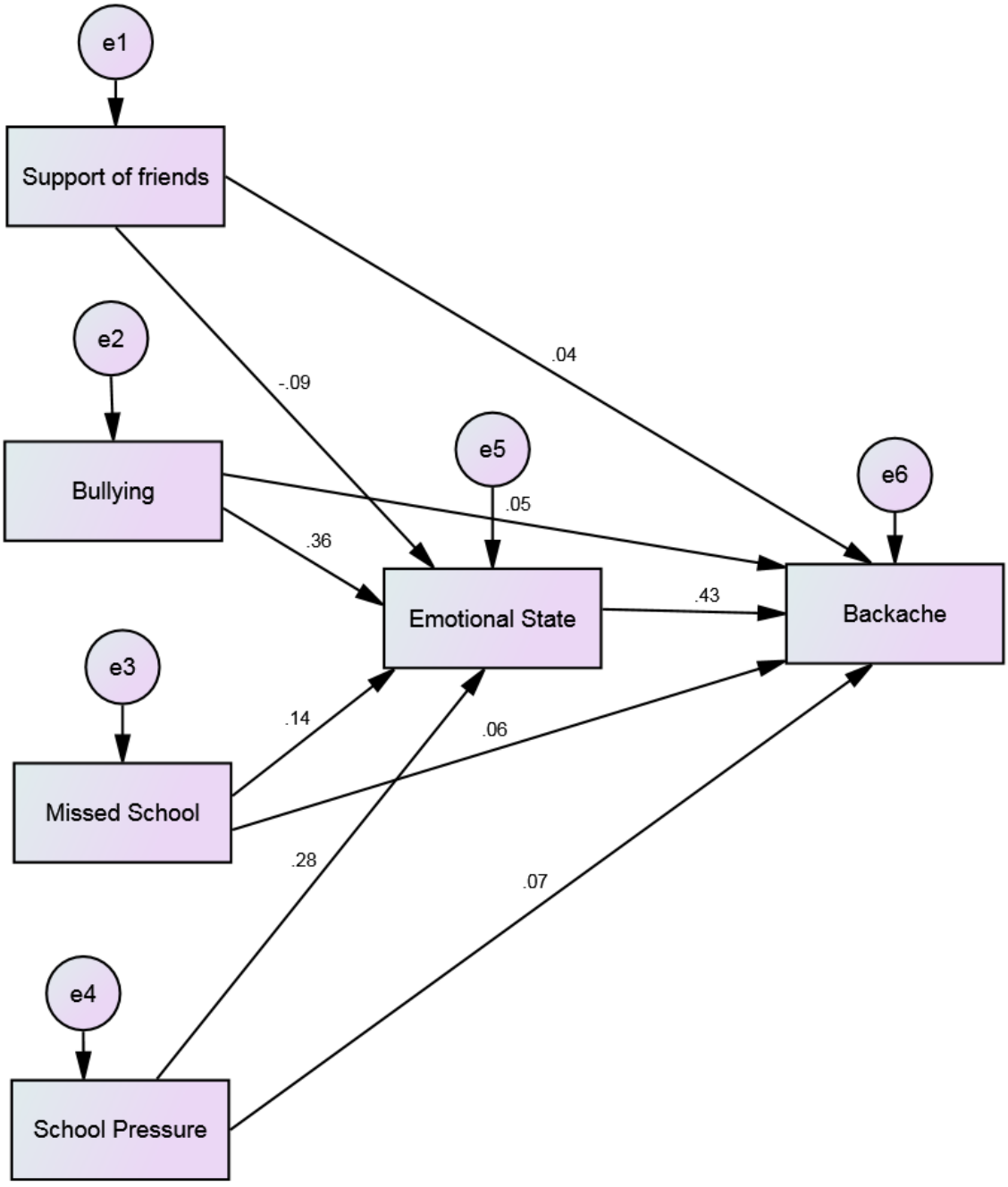


Figure 4b. Path Model: Girls Backache $\chi^2(15) = 143.085$, $p < .001$, CMIN/df= 23.848. CFI= .903, RMSEA= .105

Table 6c

Path Model Backache

Backache and Emotional State							
	Boys (N=1844)				Girls (N=2056)		
IV's	Direct (SE)	Indirect (SE)	Total (SE)	**IV's**	Direct (SE)	Indirect (SE)	Total (SE)
School Satisfaction	-.068 (.024)**	-.142 (.014)***	-.210 (.027)***	**Support of Friends**	.040 (.019)*	-.039 (.010)***	.002 (.023)
Missed School	.063 (.023)**	.056 (.014)***	.119 (.029)***	**Bullying**	.046 (.025)	.155 (.013)***	.202 (.026)***
Deprivation	-.049 (.021)*	.074 (.012)***	.025 (.025)	**Missed School**	.060 (.023)**	.059 (.011)***	.120 (.025)***
Puberty	.048 (.020)*	.002 (.012)	.050 (.025)*	**School Pressure**	.073 (.022)***	.122 (.011)***	.194 (.022)***
Emotional State	.482 (.025)***		.482 (.025)***	**Emotional State**	.429 (.024)***		.429 (.024)***

Note. * $p < .05$ ** $p < .01$ *** $p < .001$

Aim 4d. Among the psychosocial variables found to be statistically independently associated with somatic pain, we aim to measure associations directly and indirectly through emotional state.

The results of the two separate path analysis for aim 4d as illustrated in Figure 5a and 5b are shown in results of the standardised path coefficients, bootstrapped standard errors and p-values in Table 6d. The profile of fit statistics was reasonable but imperfect fit of the model to the data with some indices meeting specific criteria but other not. For both boys and girls there was a strong direct association between emotional state and somatic pain when even controlling for (psychosocial factors), which showed that there is unique substantial relationship between emotional state and somatic pain not accounted for by the other factors. For boys the relationship between school satisfaction and somatic pain is largely accountable by emotional state (β = -.183, SE=.017). For girls the relationship between bullying and somatic pain was largely accountable by emotional state (β = .200, SE=.015). Similarly, school pressure was largely accountable through an indirect relationship with emotional state (β = .154, SE=.013) as well as overall subjective health (β = -.101, SE=.013). Similarly, for somatic pain missed school operates evenly through both direct and indirect paths in their association. Therefore, aim 4d is supported highlighting the psychosocial variables from aim 2 operating through both direct and indirect pathways with emotional state which is different between genders.

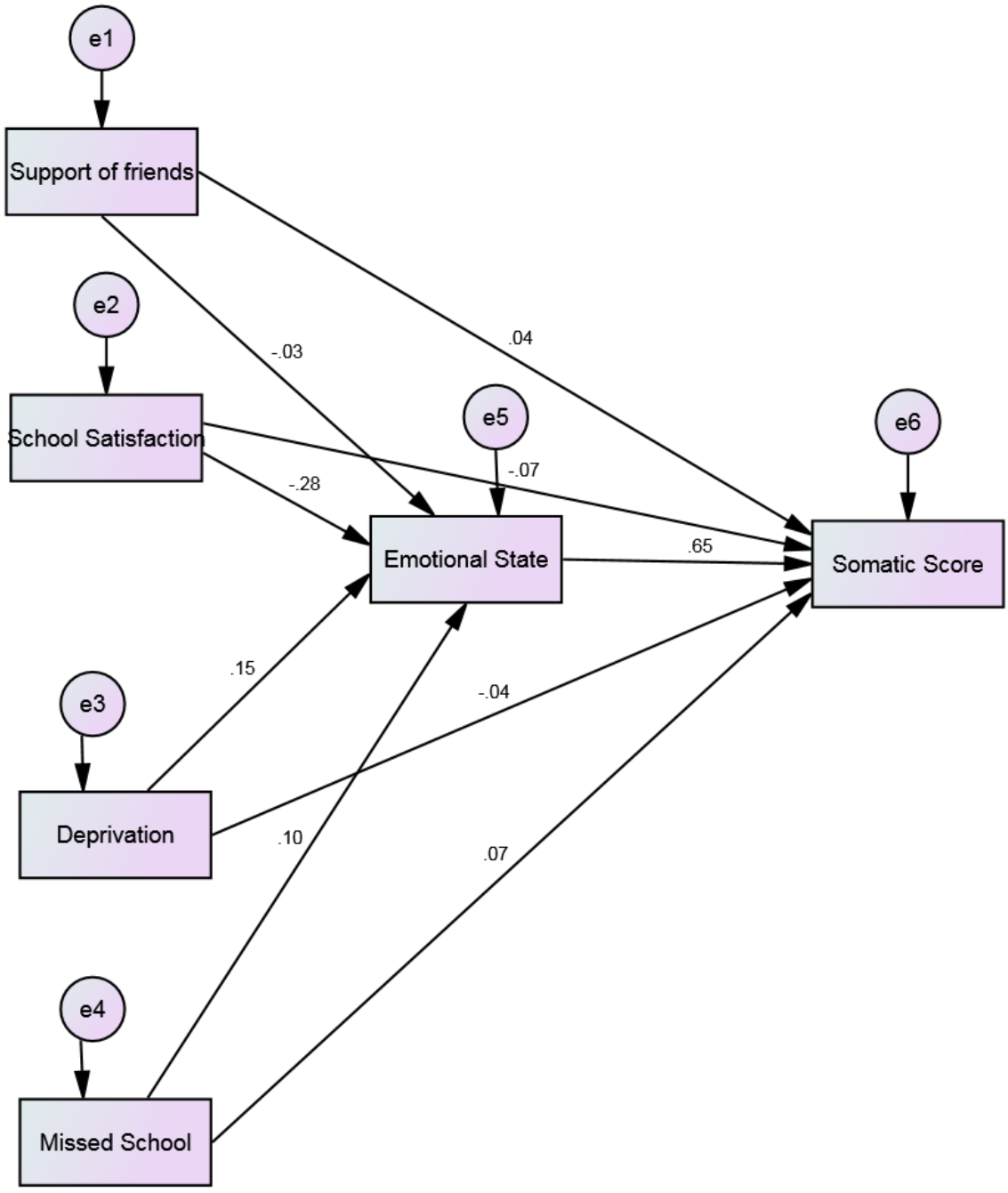


Figure 5a. Path Model: Boys Somatic Pain $\chi^2(15) = 135.473$, $p < .001$, CMIN/df= 22.579. CFI= .918, RMSEA= .106

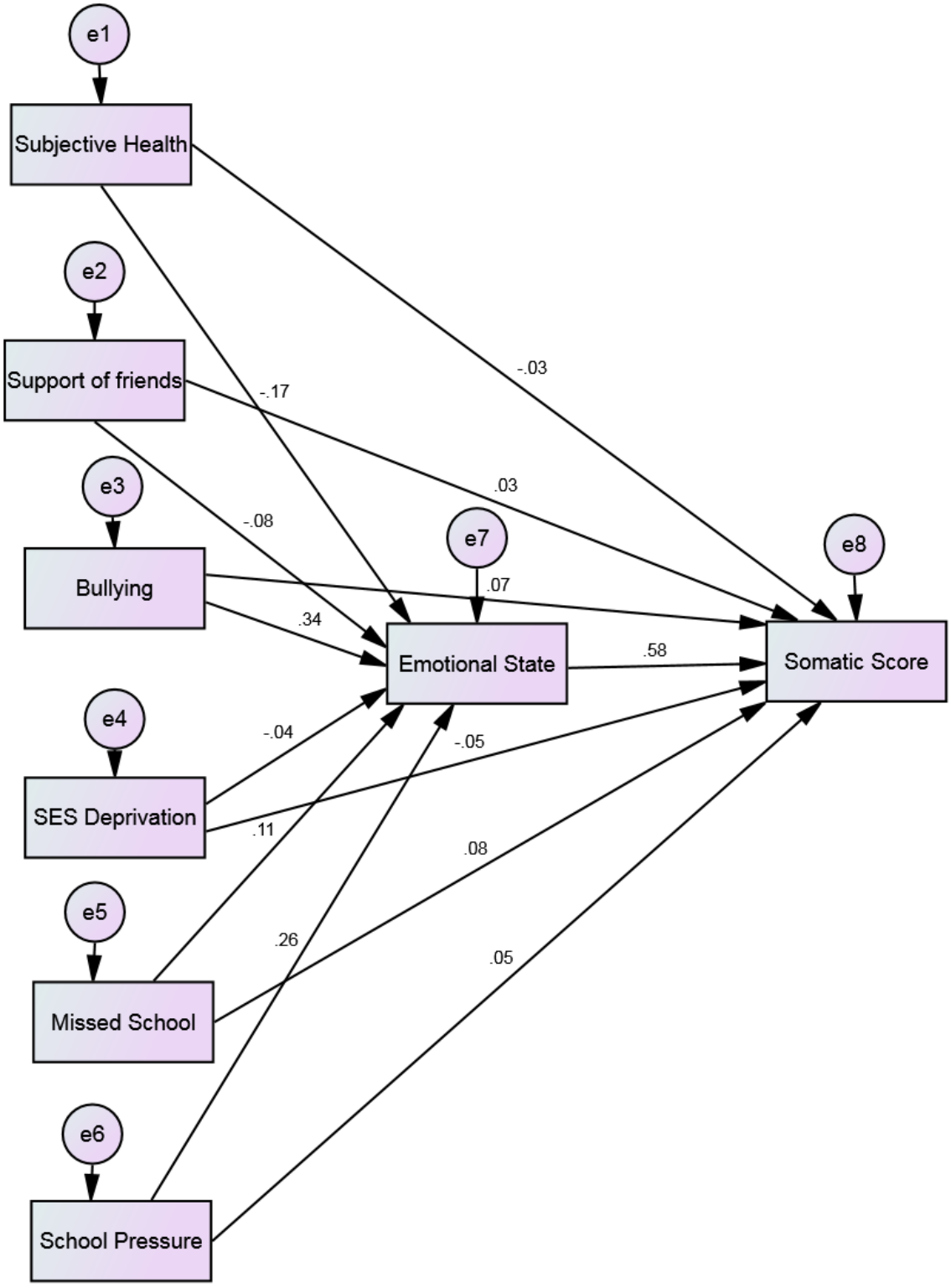


Figure 5b. Path Model: Girls Somatic Pain $\chi^2(21) = 361.712$, $p < .001$, CMIN/df= 24.114. CFI= .852, RMSEA= .107

Table 6d

Path Model Somatic Pain

			Somatic Pain and Emotional State				
		Boys (N=1909)				Girls (N=2032)	
IV's	Direct (SE)	Indirect (SE)	Total (SE)	**IV's**	Direct (SE)	Indirect (SE)	Total (SE)
Support of Friends	.037 (.018)*	-.022 (.016)	.016 (.025)	**Overall Subjective Health**	-.027 (.019)	-.101 (.013)***	-.128 (.022)***
School Satisfaction	-.067 (.020)***	-.183 (.017)***	-.250 (.026)***	**Support of Friends**	.028 (.019)	-.044 (.013)***	-.016 (.024)
Deprivation	-.043 (.019)*	.099 (.015)***	.057 (.025)*	**Bullying**	.071 (.022)**	.200 (.015)***	.271 (.024)***
Missed School	.073 (.021)***	.063 (.018)***	.135 (.031)***	**SES Deprivation**	-.046 (.022)*	-.024 (.013)	-.070 (.025)**
Emotional State	.648 (.018)***		.648 (.018)***	**Missed School**	.083 (.018)***	.067 (.014)***	.150 (.023)***
				School Pressure	.048 (.019)*	.154 (.013)***	.202 (.021)***
				Emotional State	.582 (.020)***		.582 (.020)***

Note. * $p < .05$ ** $p < .01$ *** $p < .001$

Chapter Four – Discussion

4.1 Key Results

The current study sought to investigate the associations between biological, psychological and social predictors on different somatic pain types, identify moderators of the relationship between emotional state and somatic pains (headache, stomach-ache and backache). To also investigate whether psychosocial predictors operate through direct or indirect pathways via emotional state in their prediction of somatic pain types in Australian adolescents. Past research has demonstrated pairwise associations between individual constructs of biological, psychological and social predictors having associations with individual pain types such as headache, stomach-ache and backache (King et al., 2011; Kröner-Herwig et al., 2011; LeResche, 2011; Reeve, 2000; Swain et al., 2014; Uphoff et al., 2013). Currently there is a paucity of studies which have evaluated the possible integrated relationships of the biopsychosocial framework and somatic pain in a large generalisable study of Australian adolescents, which we aimed to address.

4.2 Summary of Findings

Aim one of the present study evaluated the association between potential predictors and somatic pain frequency for both boys and girls. The relationships between biological, psychological and social predictors with somatic pain have been examined in isolation of one another (King et al., 2011) and have been individually recognised as important factors associated with somatic pain, however there is a paucity of knowledge around the relative contribution of

these biopsychosocial factors broadly on somatic pain. Recent studies have shown that girls experience more pain than boys (King et al., 2011; Swain et al., 2014). The current study identified that negative emotional state is strongly associated with the frequency of all somatic pain types (individual and combined) above other predictors with no difference between boys and girls. This strengthens current understanding of the effect of negative emotional state and low mood has on pain experiences in adolescence (Barlow et al., 2014; Damsgaard et al., 2014; Ferguson, 2013; Wilner et al., 2014). However, further studies are needed to explore additional individual personality factors such as neuroticism which may be important in the development of mood disorders and increase the frequency of somatic pain frequency (Barlow et al., 2014; Wilner et al., 2014). This is important as identifying possible personality traits which affect emotional state and thus somatic pain frequency may aid in the development of targeted primary prevention and intervention studies.

The present study found the predictors associated with stomach-ache are related to quality of life measures, compared to headache, backache and somatic pain score shown in aim two. The direction of these relationships is unknown in the current study given the cross-sectional design, however it is consistent with other studies showing that stomach-ache or abdominal pain is closely linked to feelings of sadness, changes in mood such as anxiety and depression associated with quality of life measurements (Brun Sundblad, Saartok, & Engström, 2007; King et al., 2011; Stanford, Chambers, Biesanz, & Chen, 2008). In population level studies of adults links identified between psychological disorder (such as anxiety, stress and depression) operating along a brain-body axis (Cunningham et al., 2013; Jones, Dilley, Drossman, & Crowell, 2006) as a neurological dysregulation presenting as recurrent abdominal pain (Kim & Chang, 2012) however this is not well established within an adolescent population to date (Cunningham et al.,

2013). This is important as further longitudinal studies are needed to investigate whether psychological traits and quality of life measures may be learnt or developed through adolescence and the impact these traits have on somatic pain types.

Socially, adolescence is a time of transition from relying on parental influence and moving toward developing relationships with peers and friends (Sigelman C, 2006). It is thought that having a stable family structure, good peer relationships, absence of negative social interactions (bullying) and a positive school environment are associated with less somatic pain and mood disorders (Larson et al., 2002; Ottova et al., 2012). The current study shows that potential conflicts with peers and bullying, missed school and school satisfaction are moderately associated with somatic pains with no significant difference between boys and girls. Research shows that bullying is moderately associated with pain experiences and mood disorders due to a dramatic increase in stress associated with a distinct lack of peer support leading to social isolation and bullying through adolescence (Anteghini et al., 2001; Blum et al., 2003; Ottova et al., 2012; Viner et al., 2012). This supports the hypothesis that the relationships established through adolescence are crucial in establishing proper development, important in minimising both psychological and social stressors which are associated with increased somatic pain frequency (Anteghini et al., 2001; Arnett, 1999; Blum et al., 2003; Hankin et al., 1998; Larson et al., 2002; Ottova et al., 2012; Viner et al., 2012).

Aim three sought to evaluate whether the relationship between negative emotional state and somatic pain types were moderated by social predictors or pubertal development for both boys and girls. Analysis of this nature has not been undertaken for biological, psychological and social predictors and somatic pains for adolescents in the literature to date. For aim three bullying had positive moderating effects in the relationship between negative emotional state and headache,

stomachache and somatic pain for boys. This means that adolescents who are being bullied are more likely to experience a stronger relationship between negative emotional state and somatic pain. For girls bullying is a positive moderator in the relationship between emotional state and stomach-ache only. In contrast the current study identified that support of closest friends acts as a negative moderator in the relationship between negative emotional state and backache only shown in Table 5c. This means that greater support of friends reduces the positive effect of negative emotional state on backache for girls, which is to be expected (Cavallo et al., 2006; Ottova et al., 2012). In contrast, there was an opposite direction of moderation effect for boys: support of closest friends acts as a positive moderator in the relationship between negative emotional state and headache shown in Table 5a and somatic pain shown in Table 5d. This may be suggestive that girls are more reliant on social networks established with peers for support compared to boys and those who don't have the support are more susceptible to somatic pain, which is consistent with recent research (Cavallo et al., 2006; Ottova et al., 2012).

Aim four in the current study highlights for bullying it is associated via an indirect pathway through emotional state for stomach-ache shown in Table 6b, backache shown in Table 6c and somatic pain shown in Table 6d for girls. This supports current studies suggesting that bullying induces undue stress on the adolescent which affects sadness, changes in mood such as anxiety and depression which is associated with increased somatic pain frequency (Brun Sundblad et al., 2007; King et al., 2011; Ottova et al., 2012; Stanford et al., 2008; Viner et al., 2012). These findings strengthen the central sensitisation theory where undue stressors activate a feed-forward mechanism which sensitises complex neuronal networks leading to pain (Brosschot, 2002). However, the direction of these relationships is not well understood with the current study being

cross-sectional in design and a paucity of longitudinal data available in the literature, causal pathways cannot be inferred.

Previous research has shown that school environmental factors such as school satisfaction and school pressure are also significantly associated with somatic pain in adolescents (Ottova et al., 2012; Torsheim et al., 2004). The current study showed that the relationship between school satisfaction, missed school and school pressure were moderately associated with somatic pain types. Connectedness to community through family, peers and school are important factors in reducing somatic pain experiences (Dey, Jorm, & Mackinnon, 2015; Due et al., 2011; Mackenbach et al., 2008; Viner et al., 2012). The current study also highlighted that the relationship between school satisfaction and school pressure operated through an indirect pathway for headache, backache and somatic pain through emotional state; whereas missed school operated evenly through direct and indirect effects in their relationship with somatic pains through emotional state. These findings only confirm the importance of emotional state in the association with somatic pains, however the direction of association cannot be established in this study due to the data being cross-sectional. It is plausible to also suggest that adolescents who experience more somatic pain are likely to miss more school (Bakoula, Kapi, Veltsista, Kavadias, & Kolaitis, 2006; King et al., 2011).

The moderating effects of school-based measures on the relationship between negative emotional state and somatic pains in aim three, showed that both boys and girls had positive moderating effects of missed school on the relationship between negative emotional state and stomach-ache shown in Table 5b. This means that missing more school leads to a stronger association between negative emotional state and stomach-ache in the current study. Whereas school satisfaction has negative moderating effects on the relationship between negative

emotional state and stomach-ache shown in Table 5b, backache shown in Table 5c and somatic pain shown in Table 5d for boys. In turn, meaning that greater school satisfaction leads to a reduced association between negative emotional state and stomach-ache, backache and somatic pain. Interestingly girls do not have any significant moderating effects for school satisfaction on the relationship between negative emotional state and somatic pain types. These are both important to explore because adolescents with somatic pain are not only more likely to miss school and do poorly academically (Bakoula et al., 2006; Campo, 2012) but also withdraw from social activities and internalise symptoms (King et al., 2011; Palermo, Eccleston, Lewandowski, Williams, & Morley, 2010), which are both significant predictors of somatic pain and mood disorders (Dunn et al., 2011; Eccleston, Bruce, & Carter, 2006; King et al., 2011). In the current study we can only hypothesise on the direction of relationship between missed school and somatic pain due to the data being cross-sectional and it is most likely that the adolescents who experience more somatic pain miss more school (Due et al., 2011; Kamper et al., 2016; Spurrier et al., 2003).

Pubertal development has been associated with backache in adolescents, with a study from (LeResche et al., 2005) finding that rates of back pain rose from 6% before puberty to 31% for boys and 36% for girls after puberty. The current study found weak associations between pubertal development and backache for boys only. It is thought that rapid pubertal development may have a role in back pain due to changes in pain perception (Yilmaz et al., 2005), sudden mechanical load placed on the spine (Lardon et al., 2014) and hormonal changes affecting fat composition (Vink et al., 2010). Pubertal development was not associated with headache, stomach-ache or combined somatic pain in the current study nor did it have statistically significant associations through direct or indirect pathways to backache. This is consistent with a

recent adolescent pain trajectory study by (Dunn et al., 2011) showing that there was no clear associations between pubertal development and different pain trajectories over a 3-year period. However, in the current study, pubertal development acted as a moderate negative moderator in the relationship between negative emotional state and stomach-ache shown in Table 5b and somatic pain shown in Table 5d for girls, shown in aim three. Therefore for those girls who had higher scores of pubertal development, the relationship between negative emotional state and somatic pain was weaker than girls who were lower in pubertal development. Further longitudinal data analysis of the entire adolescent years is needed to fully understand whether having rapid pubertal development is a predictor for somatic pain conditions or operates through indirect pathways through emotional state (Dunn et al., 2011; King et al., 2011; Mallen, Peat, Thomas, Dunn, & Croft, 2007; Patton & Viner, 2007; Swain et al., 2014).

It is understood that adolescents who come from higher socioeconomical disadvantage families will have poorer health status and a higher frequency of somatic pain (Mikkelsson et al., 2001; Von Baeyer & Champion, 2011). Studies have shown that material deprivation has a strong relationship with somatic pain and mood disorders (Torsheim et al., 2004). In the current study there were no statistically significant associations between material deprivation or SES deprivation and somatic pains. However, socioeconomic measures should be further explored as a result of recent studies showing significant associations with overall health equality (Due et al., 2011; Von Baeyer & Champion, 2011; Von Rueden et al., 2006). Aim three identified that there were strong negative moderating effects of socioeconomic deprivation on the relationship between negative emotional state and backache and somatic pain for boys: There was a stronger association between negative emotional state and backache and somatic pain for adolescents who rated their SES as being low. This type of moderation analysis has not been undertaken in the

literature to date, however findings of the current study highlight that there needs to be further study investigating the role of socioeconomic status has on adolescent pain experiences.

The current study identifies and evaluates important biological, psychological and social predictors in the association with somatic pain in Australian adolescents. Studies have found the link between somatic pain and psychological status in adolescents as being predictive of persistent, chronic and disabling pain in adults (Due et al., 2011; Dunn, Campbell, & Jordan, 2013). There is also evidence to support that these somatic pains may actually exist as the same underlying condition being centrally processed due to changes in the individual's feed forward mechanism which sensitises pain neural networks (Brosschot, 2002; Ottova et al., 2012) as well as changes within the biopsychosocial framework in adults (Wessely & White, 2004; Whitehead et al., 2002). Whether these associations could be learnt or developed from early life experiences, cannot be fully answered by the current study due to the data being cross sectional. However, the current study does help to highlight that there are significant associations between negative emotional state and all somatic pains, and identifies other psychosocial predictors, such as relationships with peers, school environment and socioeconomic status, as contributors to the overall somatic pain experience in Australian adolescents.

4.3 Limitations

While the results of this present study are important in identifying predictors associated with somatic pain types there are also methodological limitations which need to be highlighted. The participants evaluated were only in years 6 and 8, which only encompasses only the early timeframe of the adolescent period of life and they were not recruited specifically for somatic pain. The dataset used is large and generalisable to the Australian adolescent population,

although it is cross-sectional and therefore, causation cannot be inferred. Many of the relationships and associations evaluated are likely to be bi-directional; for example missed school is also likely to operate in the opposite direction with adolescents with higher somatic pain missing more school (King et al., 2011).

The survey was designed to capture factors across a large population of adolescents, therefore each individual factors measured may not totally reflect the construct listed, compared to smaller-scale but more tailored studies. Model fit is not ideal and therefore suggests that some variable may be missing from our hypothesis. Factors such as material deprivation had a low reliability (Cronbach's $\alpha = 0.45$), which is likely to be due to modification from the ACWP authors. This could potentially reduce some correlations seen in the current study. Further more the measure of somatic pain in this study may be different to measures of chronic or recurrent pain used in other studies. Future studies should aim to extend on the results of this study and explore multiple item measures of biological, psychological and social predictors to further evaluate constructs.

4.4 Strengths, Implications and Directions for Future Research

This study uses a large generalisable dataset representative of the Australian adolescent population and provides valuable information about various biological, psychological and social predictors associated with somatic pain. The use of a web based survey as the primary sampling method allows data collection to be easily distributed around Australian schools. The data however is cross-sectional in nature and thus limits the ability to draw causal conclusions of biological, psychological and social predictors. Similarly, the factors chosen weren't determined by the authors and thus may have limitations in study design. Adolescent research is often

difficult to undertake due to the logistics related to school based, ethical and legal considerations undertaking a secondary analysis of cross-sectional data is the most feasible option when at looking at adolescent somatic pain at the population based level. The current study aids future longitudinal studies by identifying important biological, psychological and social predictors important in their association with somatic pain types.

In the current study, emotional state, is strongly associated with somatic pain types; although, emotional state was measured from a one item measure. Therefore, immediate future studies should aim to explore these relationships further with questionnaires and surveys evaluating psychological factors such as mood disorders and possible developmental personality traits such as neuroticism (Barlow et al., 2014; Ferguson, 2013; Wilner et al., 2014) that are important in association with somatic pain types. Studies of this nature also facilitate future research directions, as it identifies the most important biological, psychological and social predictors associated with somatic pain. This aids in the targeted collection of factors for longitudinal study design, which will allow for the development of temporality and causation models to guide future intervention based and primary prevention studies aimed at reducing the burden of somatic pain in Australian adolescents.

4.5 Conclusion

The current study has investigated the biological, psychological and social predictors of somatic pain, the role of moderators in the relationship between emotional state and somatic pain and evaluated the direct and indirect effects of psychosocial variables through emotional state to somatic pain in Australian adolescents. It identifies that emotional state is the most significant predictor associated with all somatic pain types, which is similar for both boys and girls. The

current study aids future prospective studies evaluating the role of emotional state in prevention and intervention of adolescents with somatic pain. Similarly, predictors relating to relationships with peers (bullying and conflict of friends) and school environment (missed school and school satisfaction) are moderately associated with somatic pain. This is important as incorporating the biopsychosocial framework in future prevention studies to better treat the whole pain experience in adolescence. The study identified that psychosocial variables such as bullying, support of friends and school satisfaction moderate the relationship between negative emotional state and somatic pains, not explored in the current literature. Interestingly we found that rapid pubertal development was not significantly associated with somatic pain types of Australian adolescents in years 6 and 8. Understanding the predictors of somatic pain in adolescents is important in exploring which are strongly associated across the life course to better aid prevention and intervention studies in the future to help reduce the frequency of somatic pain.

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Appendix A:

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MACQUARIE University
SYDNEY·AUSTRALIA

24 March 2016

Dear Professor Jones

Reference No: 5201600085

Title: *Interactions Between Biopsychosocial Determinants of Somatic Pain in Australian Adolescents: A Nationally Representative Survey*

Thank you for submitting the above application for ethical and scientific review. Your application was considered by the Macquarie University Human Research Ethics Committee (HREC (Human Sciences & Humanities)).

I am pleased to advise that ethical and scientific approval has been granted for this project to be conducted by:

- Macquarie University

This research meets the requirements set out in the *National Statement on Ethical Conduct in Human Research* (2007 – Updated May 2015) (the *National Statement*).

Standard Conditions of Approval:

1. Continuing compliance with the requirements of the *National Statement,* which is available at the following website:

http://www.nhmrc.gov.au/book/national-statement-ethical-conduct-human-research

2. This approval is valid for five (5) years, subject to the submission of annual reports. Please submit your reports on the anniversary of the approval for this protocol.

3. All adverse events, including events which might affect the continued ethical and scientific acceptability of the project, must be reported to the HREC within 72 hours.

4. Proposed changes to the protocol and associated documents must be submitted to the Committee for approval before implementation.

It is the responsibility of the Chief investigator to retain a copy of all documentation related to this project and to forward a copy of this approval letter to all personnel listed on the project.

Should you have any queries regarding your project, please contact the Ethics Secretariat on 9850 4194 or by email ethics.secretariat@mq.edu.au

The HREC (Human Sciences and Humanities) Terms of Reference and Standard Operating Procedures are available from the Research Office website at:

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics

The HREC (Human Sciences and Humanities) wishes you every success in your research.

Yours sincerely

Dr Karolyn White
Director, Research Ethics & Integrity,
Chair, Human Research Ethics Committee (Human Sciences and Humanities)

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research* (2007) and the *CPMP/ICH Note for Guidance on Good Clinical Practice*.