# Physical Correlates of Sexual Orientation: The Association of Height, Birth Weight, and Facial Structure with Sexual Orientation.

by

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A thesis
submitted in partial fulfillment
of the requirements for the degree
Doctor of Philosophy

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St. Catharines, Ontario

August 2016

**Abstract**

Researchers have examined whether certain physical characteristics are associated with sexual orientation to gain insight into the mechanisms that may be implicated in its development. Three relatively new and/or understudied physical correlates (height, birth weight, facial structure) were investigated to determine whether they are reliably associated with sexual orientation and to gain insight into the specific mechanism(s) that may be driving the association between these physical correlates and sexual orientation. In Study 1, gay men were found to be shorter, on average, than heterosexual men in a nationally representative US sample. There was no significant height difference between lesbian and heterosexual women. No evidence was found that stress and nutrition at puberty mediated the association between sexual orientation and height in men. Thus, other mechanisms (e.g., prenatal hormones, genetics) likely explain the sexual orientation-height link. In Study 2, firstborn gay male only-children had, on average, a significantly lower mean birth weight than firstborn children in four other sibship groups. There was also evidence of increased fetal loss among mothers of gay male only-children. Birth weight and fetal loss have been shown to be indicators of a mother's immune system responding to a pregnancy. Thus, Study 2 provides support for the idea that a maternal immune response (and one that appears to be distinct from the maternal immune response hypothesized to explain the traditional fraternal birth order effect) is implicated in sexual orientation development. In Study 3, lesbian and heterosexual women differed in 17 facial features (out of 63) at the univariate level, and four were unique multivariate predictors. Gay and heterosexual men differed in 11 facial features at the univariate level, and three were unique multivariate predictors. Some of the facial features related to sexual orientation implicated a sexual differentiation related mechanism (e.g., prenatal hormones), whereas others implicated a non-sexual differentiation mechanism (e.g., developmental instability) to explain the sexual orientation-facial structure association. In addition to extending the empirical literature on the physical correlates associated with sexual orientation, the studies included in this dissertation extend our understanding of the various mechanisms likely implicated in the development of sexual orientation.

**Key words**: sexual orientation; physical characteristics; height; birth weight; facial structure; miscarriage

**Acknowledgements**

The last four years have been an incredible journey. There are many special individuals without whom the completion of this dissertation and the PhD would have been difficult. Their constant support, understanding, patience, advice, and motivation is noticed and greatly appreciated.

I am forever grateful for the mentorship of my supervisor, Dr. Anthony Bogaert, also known as Tony. It is so difficult to express my gratitude with words…they simply are not enough! Tony truly lived up to the definition of a mentor, “an experienced and trusted advisor.” His advice has never led me down a path that was not good for me as an individual or for me as a student. In addition to guiding me with his expertise in our field and asking me several thought provoking and insightful questions, he took the time to get to know me. He got to know my strengths and weaknesses and found a way to ensure that I could let my strengths shine and I could acknowledge and work on my weaknesses. He has been ethical, beyond reasonable, beyond patient, comforting, wise, thoughtful, open, motivating, and caring throughout these past four (six in total) years. He has also taught me great lessons (often accompanied by various sayings, e.g., “a bird in the hand is worth two in the bush”), not only in our field of research, but also in how to be a good person.

I am extremely grateful for the helpful and supportive atmosphere created by my committee members, Dr. Michael Ashton and Dr. Cheryl McCormick. I have learned so much from the both of you! My statistics knowledge and writing will be forever thankful. Not only have you shared your expertise with me, you have allowed me to ask whatever questions I had, openly and honestly, in an environment that allowed me to learn and deepen my understanding of the concepts. Your support and guidance has helped to turn me into a thoughtful and reflective researcher.

In addition to my committee members, there are other Faculty who have been supportive of my research, course work, and other (both on-campus and off-campus) activities. Dr. Gordon Hodson, Dr. Tim Murphy, Dr. Danielle Molnar, Dr. Stefan Brudzynski, Dr. Tanya Martini, Dr. Cameron Muir, Dr. Nancy DeCourville, Dr. Michael Busseri, Linda Pidduck, Linda DiRaddo, Joanne Boekestyn, and Joanne Boucher-Johnson. Whether it is chatting with me, taking a bit of extra time to check in with me, helping me make my research visions a reality, helping me with all my forms, or buying Girl Guide cookies, you have made my time at Brock easier to navigate and wonderful!

My co-authors (not listed before in the Acknowledgements), your expertise and guidance have helped me master my understanding and my writing of some of the most difficult concepts. I will always be grateful for the opportunities you have provided me with and for the chance I have had to work with you: Dr. Doug VanderLaan, Dr. Ray Blanchard, and Dr. Ken Zucker.

I am overwhelmingly grateful for the support of my parents, Margaret and Miroslaw Skorski, and my brother, Mateusz, throughout these past four years. You have always challenged me when I needed it and provided support at those moments that were not so easy. Your constant and caring reminders that I'm "almost there" motivated me to get through some of the toughest moments in graduate school. You have also taken the time to understand what I am doing and how important it is to me. I would not be the person I am today without your reminders about hard work, ethics, your caring, and your support. Thank you.

I also could not finish this journey without the constant support and understanding of my friends and peers. There are too many of you to name and I apologize if I have forgotten anyone. You have allowed me to vent, gone to the gym with me to de-stress, gone for walks or hikes with me, gone on vacation with me, gone to see Madonna with me, have been patient and understanding, helped me with my writing, helped me with my research studies, and overall just been awesome. Adrian, Alicia, Alison, Amanda, Amber, Andrea, Andrew, Ashley K., Ashley F., Beenish, Catherine, Chao, Evelina, Ivonne, Jasmine, Jill, Jose, Josh, Kasia, Kevin, Laura, Leanne, Luanne, Mark, Martin, Maureen, Morag, Narnia, Nathalie, Nicole, Rose, Sam, Sarah, Tammy, Taysa-Rhea, and Tina. Even in the little ways, your support has meant and continues to mean a great deal to me.

Last, but certainly not least, the amazing research teams that I have worked with over the years. Your dedication and the quality of your work are impressive, and the work in this dissertation could not have been done without you. Those who helped to collect blood samples and questionnaire data for the mother study (e.g., Kait, Kelsey, Nimesha, Dylan, Mark, Ivonne), those who helped to collect the face photos at several Prides across Canada (e.g., Karolina, Charles, Shawn) and who helped with inputting the face photos into FaceGen (e.g., Brandon), those who have helped with the ELISA and ELISpot analyses (Dr. Adam MacNeil, Jose), and Jonathan Therien, the “FAHS IT guy” who sat with me while I tried to get the computer ready to analyze the Add Health data and answered my seemingly endless list of questions. Thank you for sharing your time, skills, and knowledge.

To all the curious souls, past and present, I think Albert Einstein nailed it: “If we knew what it was we were doing, it would not be called research, would it?”

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# Chapter 1: General Introduction

## 1.1 Overview

Over the last 30 years, much academic and public interest has occurred concerning the definition, correlates, and etiology of sexual orientation. The research included in this thesis continues this tradition by examining certain physical correlates of sexual orientation. Physical correlates have been investigated in order to provide insight into the (biological) development of sexual orientation.

One major goal of the research presented here was to replicate existing, but relatively new, correlates of sexual orientation. Another major goal was to gain insight into the specific mechanism(s) that may be leading to the association between a certain physical correlate and sexual orientation. Thus, the examination of the associations between sexual orientation and physical correlates was done with a goal of elucidating further evidence for a specific mechanism(s) that may be involved in linking the physical correlate to sexual orientation, ultimately providing some more information about the development of sexual orientation. Specifically, a major goal of this thesis was to examine the associations between sexual orientation and height, between sexual orientation and birth weight, and between sexual orientation and facial structure, in order to glean information about the mechanisms that may be involved in the development of sexual orientation. Height has been examined in some previous studies, whereas birth weight and facial structure have received relatively less attention in the research literature on the physical correlates of sexual orientation.

The outline of the thesis is as follows. The next section of the first chapter (1.2) is based on a published review chapter in a book and provides some background on the biological influences to the development of sexual orientation, including the physical correlates of sexual orientation. In the following sections (1.3 and 1.4) of the first chapter, the background and objectives of the three empirical studies on the associations between sexual orientation and height, between sexual orientation and birth weight, and between sexual orientation and facial structure, respectively, will be discussed, followed by a summary (1.5) of these objectives. The second chapter of this thesis contains the first study (2.1-2.5), on the association between sexual orientation and height. The third chapter contains the second study (3.1-3.5), on the association between sexual orientation and birth weight. The fourth chapter contains the third study (4.1-4.5), on the association between sexual orientation and facial structure. The fifth and final chapter of this thesis contains the General Discussion (5.1-5.5).

**1.2 Background Literature**

Note: This section is based on the following article, with permission: Skorska, M. N., & Bogaert, A. F. (2015). Sexual orientation: Biological influences. In J. D. Wright (Ed.) *International Encyclopedia of the Social & Behavioral Sciences* (2nd Ed., Vol. 21, pp. 773-778). Oxford, UK: Elsevier.
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In 1973, "homosexuality" was removed from the Diagnostic and Statistical Manual of Mental/Psychiatric Disorders. The removal of homosexuality as a mental disorder has had an impact on society, and has stimulated copious amounts of research on the complex trait of sexual orientation over the last 15 to 30 years. This research not only informs us about sexual dimorphisms (e.g., gender roles), atypical sexual attraction, and non-traditional aspects of sexual orientation (e.g., asexuality), but also provides insight into the definition and origins of sexual orientation. This article will summarize the current state of research into the biological origins of sexual orientation. After an introduction into the definition of sexual orientation and the biological approach to examining sexual orientation development, the literature on several biological influences are discussed in relation to hormones, genetics, the brain, the body, and the fraternal birth order effect. Future directions in this area of research will conclude the article.

### 1.2.1 What is Sexual Orientation?

There are many aspects to an individual's sexual preferences. For example, an individual may prefer individuals of a certain age, ethnicity, body type, or personality, to name a few, for their sexual partner(s). A core aspect of an individual's sexual preferences is, however, their sexual orientation. Although there is no consensus on an exact definition of sexual orientation, generally sexual orientation concerns the sex that an individual is interested in for his/her sexual partner(s). Definitions of sexual orientation can include two components: a psychological component concerning attraction to or fantasies about a certain sex, and a behavioral component concerning the sex of a partner with which an individual actually engages in sexual acts. In recent years the field has shifted toward an emphasis on the psychological component—specifically sexual attraction—in defining sexual orientation.

Most researchers categorize sexual orientation into three main categories: homosexual, heterosexual, and bisexual, although there is debate among researchers whether sexual orientation is categorical or continuous in nature. "Homosexual" describes an orientation toward the same sex; "heterosexual" describes an orientation toward the other sex; and "bisexual" describes an orientation toward both sexes. Labels of straight (or heterosexual), gay (or homosexual man), and lesbian (or homosexual woman) are often used interchangeably with the homosexual and heterosexual categories. Some recent sexual orientation theorists have suggested a fourth main category of sexual orientation, asexual, the absence of sexual attractions for others, although asexual individuals are much less studied than the three traditionally defined groups—gay/lesbian, straight, and bisexual—mentioned above. It is important to note that although these categorization labels for traditional groups (e.g., gay, lesbian, bisexual) are used in several studies, they are confounded with identity labels (e.g., not all individuals who engage in same-sex behavior identify as gay, lesbian or bisexual). Thus, this article will use the terms same-sex orientation[1], both-sex orientation and other-sex orientation to refer to gay and lesbian individuals, bisexual individuals, and straight individuals, respectively. Various epidemiological studies have indicated that approximately 2-5% of men, and approximately 1-2% of women have a predominant or exclusive orientation toward the same sex, approximately 1% of women and men have an orientation toward both sexes (LeVay, 2010), and approximately 1% of the population may be asexual (Bogaert, 2004, 2012).

### 1.2.2 The Biological Approach

Several approaches have been taken to explain the development of variation in sexual orientation. These include psychoanalytic, learning, and biological approaches,

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[1] Note that throughout most of this document same-sex orientation, other-sex orientation, and both-sex orientation will be used in lieu of the common identity labels gay/lesbian/homosexual, straight/heterosexual, bisexual; however, in circumstances where an article was submitted to a journal that commonly uses the identity labels, the identity labels were kept in place to be consistent with the submitted article.

with the two former approaches emphasizing a nurture or environment perspective. Recent researchers have placed an increased emphasis on nature or a biological perspective to investigating the cause of sexual orientation. This emphasis is partly due to the failure of the other approaches in explaining certain aspects of sexual orientation development.

An emphasis on biological influences to sexual orientation development was largely born out of animal studies that suggested early (i.e., prenatal and neonatal) exposure to testosterone and/or estrogen, which are hormones produced by the gonads, have different effects on the brain, adult sexual behavior, and adult sexual partner preference of males and females in species such as rats, monkeys and sheep. Current models also include the influence of genes in sex determination and sexual differentiation. For example, the *Sry* gene, which is encoded by the Y-chromosome, determines whether the gonads develop into testes or ovaries, and the gonads' hormones, especially testosterone released from the testes, influence the physical development and neural development of males and females. There is some evidence that these organizational effects of gonadal hormones influence adult sexual behaviors and adult sexual partner preferences (see Hines, 2011 for a review). Note, that we are using the word influence to indicate that biology exerts some impact on the development of sexual orientation; however, this does not mean that it directly determines sexual orientation in a fixed manner. With this knowledge about the sexual development of male and female animals, coupled with evidence that some animals engage in same-sex oriented and/or both-sex oriented sexual behaviors, researchers studying the origins of sexual orientation development in humans began to explore several biological variables and their relation to sexual orientation development in humans. Some of the key findings of this research are outlined in the following sections.

### 1.2.3 Hormones

To examine the influence of hormones in sexual orientation development, researchers have examined both circulating hormone levels and prenatal hormone levels. Circulating hormone levels (sometimes called activational or reversible effects) refer to hormones that are currently circulating in adults. Prenatal hormone levels (sometimes called organizational or more permanent effects) refer to hormones present in an individual while he/she is in the womb that influence gonadal and brain development in a fetus. Researchers have generally found that there were no differences in circulating testosterone levels between men with a same-sex orientation and an other-sex orientation (Meyer-Bahlburg, 1984). However, some studies have found evidence suggesting that more masculine[2] women with a same-sex orientation, compared to more feminine women with a same-sex orientation had higher salivary testosterone levels (Pearcey, Docherty, & Dabbs, 1996; Singh, Vidaurri, Zambarano, & Dabbs, 1999). As there was not much support for the role of circulating levels of testosterone in sexual orientation development, researchers have focused on the possible influence of prenatal hormones on the organization of the fetal brain with respect to the development of sexual orientation. This research assumes that typical levels of hormones (e.g., testosterone) have been

[2] A range of gender expression occurs in individuals. There are clear differences on a group level between men and women in gender expression; however, although average differences exist between men and women, there is also a range of variability within men and within women in gender expression. Likewise, although there is evidence that same-sex attracted individuals are, on average, more gender non-conforming than other-sex attracted individuals, there is also a wide range of variability within same-sex attracted and other-sex attracted individuals in gender expression.

altered in prenatal sexual development (e.g., lowered in male fetuses; raised in female fetuses), and that this atypical exposure to prenatal hormones ultimately predisposes an individual to a same-sex orientation later on in life by affecting areas of the brain (see below) implicated in sexual orientation. Researchers cannot ethically manipulate levels of hormones in an experiment on pregnant women; however, other, more indirect or correlational lines of research have generally provided support for the role of prenatal hormones in human sexual orientation development (e.g., Ellis and Ames, 1987; Hines, 2011; Meyer-Bahlburg, 1984).

One avenue of research is to examine other atypical sexual development. For example, girls and women who have the classical form of congenital adrenal hyperplasia experience an increase in prenatal androgen (e.g., testosterone) levels produced by the adrenal glands. As a result, these girls and women have some degree of masculinized genitals. Studies conducted on the relationship between women with congenital adrenal hyperplasia and sexual orientation have found that women with the most severe forms of this condition have, on average, a reduced other-sex orientation (and also have an increased same-sex orientation; e.g., Hines, Brook, & Conway, 2004; Meyer-Bahlburg, Dolezal, Baker, & New, 2008). Boys and men (i.e., these individuals are born with the XY chromosomes) with androgen insensitivity syndrome and 5-alpha reductase deficiency experience a decreased response to androgens, which results in men with feminized genitals who are, as a result, usually reared as girls. The few studies that have been conducted on these girls suggest that as adults these women are generally interested in men for their partners; however, the results are more complicated in girls with 5-alpha reductase deficiency, as they experience masculinization at puberty and some change to be men as adults (e.g., due to cultural or medical factors) (e.g., Herdt & Davidson, 1988; Hines, Ahmed, & Hughes, 2003; Wisniewski et al., 2000). In sum, this research provides some support for the role of androgens in sexual orientation development in both women and men (e.g., Hines et al., 2003; Meyer-Bahlburg et al., 2008; Money et al., 1984).

Another avenue of research is via pregnant women who were prescribed hormones during their pregnancies. In the 1940s to 1960s, pregnant women were prescribed a synthetic estrogen, diethylstilbestrol (DES), to prevent miscarriage. Thus, these women carried fetuses that were exposed to increased levels of estrogen (which can have masculinizing effects prenatally). Some studies on the offspring of these women indicate that women who were exposed to DES were associated with an increase in same-sex orientation compared to women who were not exposed to DES prenatally (Ehrhardt et al., 1985; Meyer-Bahlburg et al., 1995). Another study did not find this association, although a less sensitive measure of sexual orientation was used (Titus-Ernstoff et al., 2003). In men, there was no supported relationship of an increase in same-sex orientation with men who were exposed to DES compared to men who were not exposed to DES (e.g., Titus-Ernstoff et al., 2003). Thus, research provides some support for the role of DES (and by implication estrogen) in sexual orientation development in women only (e.g.,Meyer-Bahlburg et al., 1995; Titus-Ernstoff et al., 2003).

The last avenue of research related to hormones discussed in this article concerns childhood behavior. Generally, boys play with male-typical toys (e.g., trucks, cars, balls) and girls play with female-typical toys (e.g., dolls, jewelry). Further, boys engage in more rough-and-tumble play than girls, and the majority of boys and girls have same-sex playmates (e.g., DiPietro, 1981; Fagot & Patterson, 1969). Retrospective and prospective studies have found that men and women with same-sex orientations recall more atypical patterns of behavior in their childhood with respect to toy preference, activity preference, and playmate choices (Bailey & Zucker, 1995; Rieger, Linsenmeier, Gygax, & Bailey, 2008). Studies conducted on girls with congenital adrenal hyperplasia have found that these girls show increased levels of childhood atypical behavior as well (e.g., Bailey and Zucker, 1995; Berenbaum and Hines, 1992; Meyer-Bahlburg et al., 2004). This suggests that prenatal androgens may influence the development of childhood playmate choices, toy interests, and activity interests. As a result, because individuals with a same-sex orientation are more likely to show increased levels of childhood atypical behavior, this provides additional support for the notion that atypical exposure to prenatal androgens is a factor related to sexual orientation development. Thus, these lines of research, and other lines of research not presented here, converge on the idea that hormones are one factor that is related to the development of sexual orientation in humans.

### 1.2.4 Genetics

Twin studies suggest that there is some degree of genetic influence on sexual orientation. That is, these studies find that monozygotic (MZ) twins, [who] share approximately 100% of their genes, have higher concordance rates than dizygotic (DZ) twins, [who] share approximately 50% of their genes, for a same-sex orientation; although the exact concordance rates differ depending on the study (e.g., Bailey, Dunne, & Martin, 2000; Langstrom, Rahman, Carlstrom, & Lichtenstein, 2010). Studies also suggest that there is an increased rate of same-sex orientation among biological siblings. Further, there is some support that the chromosomal region Xq28 on the X-chromosome is associated with same-sex orientation in men (Hamer, Hu, Magnuson, Hi, & Pattatucci, 1993); however, replication of this finding by an independent group of researchers (Rice, Anderson, Risch, & Ebers, 1999) was not successful (cf. Sanders et al., 2015) and the exact genes in this chromosomal region that are relevant to sexual orientation have not yet been identified as of the date of the writing of this review. Another study has also implicated the X-chromosome in sexual orientation development in men (Bocklandt, Horvath, Vilain, & Hamer, 2006). Female cells contain two X-chromosomes and one of them is randomly inactivated in early development in each cell. Since this inactivation is random, 50% of the X-chromosomes should be maternal in origin and 50% should be paternal in origin (i.e., because women receive one X-chromosome from their mother and the other X-chromosome from their father). Mothers of gay sons displayed skewing in X-chromosome inactivation (i.e., a non-random amount of X-activation was either paternal or maternal) and this skewing increased with an increase in the number of gay sons. Another study using molecular genetic techniques has provided some support for the role of autosomal genes (i.e., genes not on the sex chromosomes), specifically on chromosomes 7, 8, and 10, in men's sexual orientation development (Mustanski, DuPree, Nievergelt, Bocklandt, Schork, & Hamer, 2005). Although research into the genetics of sexual orientation development is not abundant, the existing research (e.g., Bailey and Pillard, 1991; Bocklandt et al., 2006; Hamer et al., 1993) suggests that there is a genetic component to sexual orientation development, with most studies conducted only in men.

From an evolutionary perspective, same-sex orientations are a paradox: genes that underlie same-sex orientations would not be passed down to future generations because same-sex sexual activity does not result in offspring via sexual reproduction. Yet, same-sex orientations exist (and likely have existed throughout human history) and thus, researchers have proposed theories/hypotheses to explain why genes for a same-sex orientation existed and continue to thrive. One hypothesis based on kin selection argues that genes for a same-sex orientation were indirectly selected for because individuals with a same-sex orientation helped increase the reproductive success of their siblings via aiding in resource accretion or caring for their children (e.g., Ruse, 1981; Vasey & VanderLaan, 2010). This hypothesis has garnered some support, at least in men, through investigations of the *fa'afafine,* a relatively feminine group of men in Independent Samoa who engage in same-sex behavior. Several studies suggest the *fa'afafine* were more likely to aid their kin than men with an other-sex orientation in Independent Samoa (VanderLaan, Petterson, & Vasey, 2016; Vasey, Pocock, & VanderLaan, 2007; Vasey & VanderLaan, 2010). Another hypothesis that has found support suggests that a same-sex orientation was related to an increased maternal fecundity (Iemmola & Camperio Ciani, 2009). There are several other hypotheses; however, these hypotheses have yet to be rigorously tested (see Rahman and Wilson, 2003 for a review). Thus, it is clear that research into the maintenance of genes for a same-sex orientation is underway; however, no clear answer to why such genes are propagated has been established (e.g., Vasey and VanderLaan, 2010).

**1.2.5 The Brain**

Researchers examining brain structures implicated in sexual orientation development have found some promising results. Aside from being the main organ of behavior (including mediating sexual attraction), the brain is an important area to study with respect to biological influences because the brain is affected by prenatal hormones (among other factors). Current biological models of sexual orientation development include the idea that prenatal hormones affect areas of the brain implicated in sexual orientation development, and these affected areas somehow influence the sexual orientation of an adult individual. Generally, it has been found that the interstitial nuclei of the anterior hypothalamus (INAH), specifically INAH-3, is implicated in sexual orientation. The hypothalamus has many functions, including roles in feeding and drinking, regulation of body temperature and reproduction/mating. Men with a same-sex orientation, and women with an other-sex orientation had the same cell volume in this area of the hypothalamus; however, the cell volumes in men with a same-sex orientation and women with an other-sex orientation were both smaller compared to men with an other-sex orientation (note: women with a same-sex orientation were not examined) (LeVay, 1991). Thus, this area seems to have been organized in a more female-typical direction in men with a same-sex orientation. This finding was partially replicated by an independent set of researchers (Byne et al., 2000). Homologous sites, such as the sexually dimorphic nucleus of the preoptic area (SDN-POA), have been implicated in mating behavior in rodents, and other mammals (e.g., Byne, 1998; Gorski, Gordon, Shryne, & Southam, 1978).

Other brain areas have been implicated in sexual orientation. For example, the suprachiasmatic nucleus was found to be larger in men with a same-sex orientation than men with an other-sex orientation by one set of researchers (Swaab & Hofman, 1990); however, the finding is difficult to interpret since the suprachiasmatic nucleus is not known to be involved in anything sexual, but is involved in regulation of circadian rhythms. A study also suggested that the anterior commissure, which is a set of smaller fibers that connect the two cerebral hemispheres of the brain, was larger in men with a same-sex orientation than men with an other-sex orientation (Allen & Gorski, 1992). Thus, this area also appeared to be slightly feminized in men with a same-sex orientation, as previous studies indicated that women with an other-sex orientation have a larger anterior commissure than men with an other-sex orientation. Another study indicated that the isthmus, a section of the corpus callosum that connects parts of the parietal lobe and temporal lobe in the left and right hemisphere, was larger in right-handed men with a same-sex orientation compared to right-handed men with an other-sex orientation (Witelson et al., 2008). The isthmus has been shown to be larger in non-right-handed individuals than right-handed individuals (see section below on the body). Further, one study demonstrated that men with an other-sex orientation have a right cerebral hemisphere that was larger than the left cerebral hemisphere, whereas women with an other-sex orientation have left and right cerebral hemispheres that were the same size (Savic & Lindstrom, 2008). Men with a same-sex orientation had the same size left and right cerebral hemispheres, similar to women with an other-sex orientation, and women with a same-sex orientation had a right cerebral hemisphere that was slightly larger than the left cerebral hemisphere, which slightly aligned with the findings in men with an other-sex orientation. Other studies have implicated the perirhinal cortex (involved in olfaction, spatial processing and memory) in women with same-sex orientation (Ponseti et al., 2007), and the amygdala in men and women with same-sex orientation (Savic & Lindstrom, 2008), with shifts in the sex-atypical way. Thus, it is clear that there are a number of important brain areas associated with sexual orientation, although much of this work has only been conducted in men, is very recent, and requires replication (see Bao and Swaab, 2011 and LeVay, 2010 for reviews). Note that although the assumption in this research is that the causal direction is such that the brain influences sexual orientation, the direction of causality is still unclear (i.e., it is possible that sexual orientation may influence the structure of the brain or a third variable influences both brain structure and sexual orientation).

**1.2.6 The Body**

Some sexual orientation researchers have examined sex dimorphic physical characteristics that are influenced by prenatal hormones, and then examined if men and women with a same-sex orientation differ from men and women with an other-sex orientation on these characteristics. Specifically, these researchers aim to determine whether these characteristics are shifted in the female-like way in men with a same-sex orientation and male-like way in women with a same-sex orientation, compared to men and women with an other-sex orientation, respectively. If physical development in men and women with a same-sex orientation is shifted in this way, then it suggests that prenatal hormones are, along with affecting these physical development characteristics, altering structures of the brain relevant to sexual orientation. This research strategy underlies a number of research programs on sexual orientation development, including 2D:4D finger ratios, handedness, otoacoustic emissions, and height.

Women have a higher ratio of the length of the second digit to the length of the fourth digit (i.e., 2D:4D finger ratio) than men. Some studies have found that prenatal androgen exposure (or androgen/estrogen exposure) underlies this sex difference (Manning, 2011; Zheng & Cohn, 2011). With respect to the association of 2D:4D finger ratios and sexual orientation, findings have been mixed. Some studies reported that men with a same-sex orientation had a more female-typical ratio, while others reported no difference or a more male-typical ratio; other studies reported that the ratio was more male-typical in only the right hand (e.g., Lippa, 2003). A recent meta-analysis concluded that women with a same-sex orientation had a more male-typical 2D:4D finger ratio, but there was no relationship between sexual orientation and 2D:4D finger ratio and sexual orientation in men (Grimbos et al., 2010).

Boys and men are more likely to be non-right-handed than girls and women, and it has been argued that handedness is determined prenatally, including a possible role for prenatal hormones (Hepper, Shahidullah, & White, 1991). Several studies have been conducted on the relationship between handedness and sexual orientation with mixed results (e.g., McCormick, Witelson, & Kingstone, 1990). A meta-analysis of 20 such studies concluded that men with a same-sex orientation are 34% more likely than men with an other-sex orientation to be non-right-handed, and women with a same-sex orientation are 91% more likely than women with an other-sex orientation to be non-right handed (Lalumiere et al., 2000).

Otoacoustic emissions are sounds produced in the cochlea (a structure inside the inner ear) that can be recorded from the outer ear. They can be spontaneously produced (i.e., spontaneous otoactoustic emissions; SOAEs) or produced after a sound is presented to the ear (i.e., click-evoked ototacoutic emissions; CEOAEs). Generally, the right ear has more SOAEs than the left ear and women have more SOAEs than men. CEOAEs are stronger in the right ear than in the left ear and women have stronger CEOAEs than men. These sex differences exist in newborns (e.g., Qi, Cheng, En, Huang, & Zhang, 2014) and thus, the sex difference is assumed to be determined prenatally by androgens. Studies have found that the number of SOAEs was decreased and the strength of CEOAEs was weakened in women with a same-sex orientation, similar to the patterns found in men with an other-sex orientation; however, there was no relationship between sexual orientation in men and the number of SOAEs and strength of CEOAEs. Thus, the otoacoustic emission research provides evidence of shifts in the male-typical way in women with a same-sex orientation in terms of SOAEs and CEOAEs; however, shifts in the female-typical way were not found in men with a same-sex orientation (McFadden, 2011; McFadden & Champlin, 2000; McFadden & Pasanen, 1998).

Men are generally taller than women (Frayer & Wolpoff, 1985; Gray & Wolfe, 1980) and prenatal hormones have been partially found to underlie this sex difference (Chernausek, Backeljauw, Frane, Kuntze, & Underwood, 2007; Clarke & Khosla, 2009; Cutler, 1997; Garnett et al., 2004; Geary, Pringle, Rodeck, Kingdom, & Hindmarsh, 2003; Jansson, Ekberg, Isaksson, Mode, & Gustafsson, 1985; Martin & Nguyen, 2004; Walker, Van Wyk, & Underwood, 1992; cf. Manning, Kilduff, & Trivers, 2013). The majority of studies conducted on the relationship between height and sexual orientation have found that men with a same-sex orientation were shorter, on average, than men with an other-sex orientation. The relationship between height and sexual orientation in women is less consistent, with the majority of studies not finding a significant difference in height between women with a same-sex orientation and women with an other-sex orientation (e.g., Blanchard & Bogaert, 1996a; Bogaert & Blanchard, 1996; Bogaert, 2010; Skorska & Bogaert, 2016).

Overall, the research programs investigating several physical markers of prenatal hormone exposure have found some support for a relationship between 2D:4D finger ratios, handedness, otoacoustic emissions, and sexual orientation in women, as well as support for a relationship between handedness, height, and sexual orientation in men. Indirectly (i.e., because these studies are correlational), these studies add support to the idea that prenatal hormones are a factor in sexual orientation development.

**1.2.7 The Fraternal Birth Order Effect**

It has been consistently shown in various samples and by independent researchers that men with a same-sex orientation tend to have an increased number of older brothers than men with an other-sex orientation (i.e., a later fraternal birth order). It has been estimated that each additional older brother increases the chance of same-sex orientation by 33%. This effect has been termed the fraternal birth order effect because the number of older sisters is not associated with sexual orientation in men, and the number of older sisters and older brothers is not associated with sexual orientation in women. Studies have ruled out potential confounding variables to explain the fraternal birth order effect, such as year of birth, age, socioeconomic status, sibship size, and parental age. Further, the fraternal birth order effect has been demonstrated even if biological older brothers were reared in a different household, and independent of the presence of adopted older brothers or older step-brothers (Blanchard & Bogaert, 1996b; 2004; Blanchard & VanderLaan, 2015; Blanchard, Zucker, Cavacas, Allin, Bradley, & Schachter, 2002; Bogaert, 1997; 2003; 2006; Bogaert & Skorska, 2011; Rahman, 2005; Schwartz, Kim, Kolundzija, Rieger, & Sanders, 2010; VanderLaan & Vasey, 2011).

An immunological explanation, termed the maternal immune hypothesis, has been proposed as an explanation for the fraternal birth order effect. Although there is no direct empirical support (yet) for the maternal immune hypothesis, there has been no feasible alternative explanation of the fraternal birth order effect to date. Specifically, the maternal immune hypothesis postulates that the mother's immune system is continuously immunized to male-specific proteins (associated with the Y-chromosome, which a mother does not have) with each successive male fetus. The increasing concentration of antibodies the mother develops after each male fetus cross the blood-brain barrier to affect specific areas in the brain associated with sexual orientation development, which would then influence the sexual orientation of the man as an adult (Blanchard & Bogaert, 1996b; Blanchard & Klassen, 1997; Bogaert & Skorska, 2011). Several lines of research indicate that transfer of material occurs from the fetus to its mother, that male-specific substances cause immune responses in women, that the relevant male-specific substances play a role in sexual differentiation of the brain (independent of prenatal hormones), and that a maternal immune response to male-specific substances affects fetal brain development (see Bogaert & Skorska, 2011 for a review). These lines of research increase the plausibility of the maternal immune hypothesis in explaining the fraternal birth order effect, and more direct empirical investigations testing this hypothesis are currently underway.

**1.2.8 Future Directions**

The study of the origins of the complex trait of sexual orientation has come a long way since 1973. Through the efforts of numerous researchers, it is clear that there is increasing evidence that biology influences sexual orientation development in humans (note, again that an "influence" does not mean that biology determines sexual orientation in a fixed manner). However, the field of sexual orientation research is still quite young and there are several questions that require answering in the future. For example, there is less sexual orientation research in women than in men (e.g., the genetics and brain research has been mostly done in men). To understand how sexual orientation develops requires a good understanding of the developmental processes in both men and women. There is also a lack of studies of individuals who are attracted to both sexes and those attracted to neither sex (i.e., asexual individuals). The field would benefit from conducting more research into these groups of individuals, as they will provide important new insights into sexual orientation development, broadly defined. As well, the findings in studies that have been conducted thus far often require replication in different samples to ensure the effects are reliable and generalizable to the wider population. For example, the majority of studies are on middle-class Caucasian Western individuals, with several studies using small sample sizes. Further, many of the studies that have been conducted thus far need to be extended to rule out alternative explanations, as they often only provide indirect support for biological mechanisms. Last, the biological research into sexual orientation development could integrate with research and theory on the environmental origins of sexual orientation to provide a complete picture of how a complex trait such as sexual orientation develops. For example, women have been argued to be more flexible in sexuality and sexual orientation compared to men’s sexuality (e.g., Baumeister, 2000). With several questions left to answer and numerous studies to be conducted, the future of research into the biological influences on sexual orientation development (and sexual orientation development more generally) looks promising.

### 1.3 Focus of Thesis

It is clear that a number of physical correlates related to sexual orientation exist, but additional research on physical development would extend this work by establishing the reliability of some of these previously examined correlates and by further investigating relatively understudied additional correlates. It is also clear that sexual orientation develops in a complex way, with likely multiple mechanisms (e.g., prenatal hormones, genetics, maternal immune response) that are involved. In this thesis, three physical correlates—height, birth weight, and facial structure—were examined in order to establish the reliability of the association between these physical correlates and sexual orientation. As a result, three particular mechanisms possibly underlying these correlates were also indirectly investigated: psychosocial stressors and nutrition; a maternal immune response; and prenatal hormones.

First, pubertal stress and pubertal nutrition were examined to determine whether they play a role in the relationship between sexual orientation and height in the Add Health data. The popular interpretation of the sexual orientation and height association has been prenatal hormones, given that height is sexually dimorphic (Frayer & Wolpoff, 1985; Gray & Wolfe, 1980; Martin & Nguyen, 2004) and partially determined by hormones (Chernausek et al., 2007; Clarke & Khosla, 2009; Cutler, 1997; Garnett et al., 2004; Geary et al., 2003; Jansson et al., 1985; Lichanska & Waters, 2008; Martin & Nguyen, 2004; Walker et al., 1992; cf. Manning et al., 2013). However, an alternative explanation involves stress, given that same-sex oriented individuals are more likely to experience stress (e.g., victimization; Collier, van Beusekom, Bos, & Sandfort, 2013; Rosario, Reisner, Corliss, Wypij, Frazier, & Austin, 2014) than other-sex oriented individuals, and there is some evidence that stress impacts height (Johnson & Gunnar, 2011; Martorell, 2010; Surkan, Ettinger, Hock, Ahmed, Strobino, & Minkovitz, 2014). A second alternative explanation involves nutrition, given that nutrition and height are related (e.g., de Beer, 2012); however, the second alternative explanation involving nutrition is less plausible because there is not much evidence to suggest that sexual orientation and nutrition are related (Boehmer & Bowen, 2009; Boehmer, Miao, Linkletter, & Clark, 2012; Deputy & Boehmer, 2010; Neumark-Sztainer, Story, Resnick, & Blum, 1998). Thus, using the Add Health data, which is a nationally representative sample of American adolescents and young adults, mediation of the sexual orientation and height relationship by pubertal stress and pubertal nutrition was tested. These alternative explanations of the sexual orientation and height relationship have not been tested in previously published research. If evidence of mediation or partial mediation is found, then psychosocial stressors at puberty could be added as another mechanism through which sexual orientation may develop. On the other hand, if no evidence of pubertal stress or pubertal nutrition mediation occurs, then other mechanisms are needed to explain the height relationship to sexual orientation.

In the second study, using a sample of mothers and their reports on their offspring, birth weight of same-sex and other-sex oriented men was used to investigate whether a maternal immune response, which is likely separate from the maternal immune response implicated in the classic fraternal birth order (FBO) effect, is associated with sexual orientation within men. This separate maternal immune response is hypothesized to explain the sexual orientation of male only-children who are same-sex oriented (i.e., independent of the number of older brothers a man has). A lower birth weight is related to a maternal immune response, a finding that has been shown in studies within animals and humans (Christensen et al., 2012; Hoff, Peevy, Spinnato, Giattina, & Peterson, 1993; Kahn & Baltimore, 2010; Kiefte-de Jong et al., 2013; Kusanovic et al., 2007; Milns &

Gardner, 1989; Nielsen et al., 2010; Silver et al., 2011). Two studies have provided some support for a lower birth weight in same-sex oriented individuals who are only-children compared to other-sex oriented individuals (Blanchard, 2012a; VanderLaan, Blanchard, Wood, Garzon, & Zucker, 2015). The study included in this thesis extends this research by examining the birth weight of firstborns. Birth weight tends to increase over succeeding pregnancies, so examining firstborns controls for this issue (Wilcox, Chang, & Johnson, 1996). This study also examines fetal loss (e.g., miscarriage) experienced by mothers of male same-sex oriented only-children compared to mothers of male children with other sibship compositions. Fetal loss is an important variable to consider because it has also (i.e., in addition to birth weight) been related to a maternal immune mechanism (Nielsen, 2011). If it is found that male firstborn same-sex oriented only-children have a lower birth weight than male firstborn children with other sibship compositions, and mothers of male same-sex oriented only-children have experienced greater fetal loss than mothers of male children with other sibship compositions, further evidence would be provided of a maternal immune response mechanism implicated in the development of sexual orientation within men. This maternal immune response, however, is hypothesized to be distinct from the immune response that is implicated in the traditional FBO effect (see also VanderLaan et al., 2015); specifically, it would be a maternal immune mechanism that leads to a same-sex orientation in men who are carried to term, but is associated with a higher likelihood of fetal loss during other pregnancies (Blanchard, 2012b).

In the third study, using a third sample, facial structure differences between same-sex oriented and other-sex oriented individuals were investigated, within men and within women. Facial structure has not been studied extensively as a physical correlate of sexual orientation (Hughes & Bremme, 2011; Valentova, Kleisner, Havlicek, & Neustupa, 2014), but is likely a good candidate to examine because facial structure is sexually dimorphic. Given that facial structure is sexually dimorphic, the last study in this thesis will examine whether facial structure is a correlate that implicates prenatal hormones in the development of sexual orientation (although additional mechanisms are possible). This last study included in this thesis extends the research literature on sexual orientation and facial structure by including a large sample of women, and by including a broad range of facial structure variables, measured quantitatively. If evidence is found that the facial structure of men with a same-sex orientation is shifted in the female-typical way compared to men with an other-sex orientation, and if the facial structure of women with a same-sex orientation is shifted in the male-typical way compared to women with an other-sex orientation, then this pattern of results would provide further support for the role of prenatal hormones in the development of sexual orientation.

## 1.4 Summary

Three empirical studies were included in this thesis to answer the following questions:

a) Study 1: What is the relationship between sexual orientation and height in a large, national probability sample within men and within women? What is the relationship between sexual orientation, nutrition, and stress in this sample? Can the relationship between sexual orientation and height be explained by group differences in nutrition and/or stress occurring during puberty, suggesting a potential role for pubertal stress and pubertal nutrition in the development of sexual orientation?

b) Study 2: What is the relationship between sexual orientation, birth weight, and sibship composition within men? What is the relationship between sexual orientation, maternal miscarriages, and sibship composition? Does the relationship between sexual orientation, birth weight, maternal miscarriages, and sibship composition suggest that a maternal immune response is implicated in the development of sexual orientation within men (that is likely separate from the maternal immune response posited to explain the fraternal birth order effect within men)?

c) Study 3: What is the relationship between sexual orientation and facial structure within men and within women? Does the relationship between sexual orientation and facial structure suggest a role for prenatal hormones in the development of sexual orientation?

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## Chapter 2: Study 1

Note: This section is based on the following article, with permission: Skorska, M. N., & Bogaert, A. F. (in press). Pubertal stress and nutrition and their association with sexual orientation and height in the Add Health data. *Archives of Sexual Behavior*. doi:10.1007/s10508-016-0800-9
Some parts of this entry differ in the published version of this article. Please contact Malvina Skorska for a list of what has been changed.

### 2.1 Introduction

Physical characteristics, and the development of them, have been a focus of study within the sexual orientation field. Specifically, this line of research has examined if gay men and lesbian women differ from heterosexual men and heterosexual women on sex-dimorphic physical characteristics. Any differences found between gay men and heterosexual men, and between lesbian women and heterosexual women, on these physical characteristics has been interpreted to suggest that the mechanism(s) responsible for the development of the implicated physical characteristics may be involved in the development of sexual orientation. A number of research programs investigating physical and physiological characteristics have undertaken this line of reasoning, including research conducted on 2D:4D finger ratios (the ratio of the length of the second digit to the length of the fourth digit; e.g., Brown, Finn, Cooke, & Breedlove, 2005; Lippa, 2003a; Manning, Churchill, & Peters, 2007; Manning & Fink, 2008), otoacoustic emissions (e.g., McFadden, 1993; 1998; McFadden & Champlin, 2000), facial structure (Skorska, Geniole, Vrysen, McCormick, & Bogaert, 2015; Valentova, Kleisner, Havlicek, & Neustupa, 2014) and height, which is the focal physical characteristic in the current study (see Balthazart, 2011; Bao & Swaab, 2011; Gooren, 2006; Hines, 2011; LeVay, 2010; Ngun, Ghahramani, Sanchez, Bocklandt, & Vilain, 2011, for reviews).

Several studies have examined an association between sexual orientation and height. Generally, the results of these studies have found that gay men and heterosexual women are shorter, on average, than heterosexual men and lesbian women, respectively (Blanchard & Bogaert, 1996a; Blanchard, Dickey, & Jones, 1995; Bogaert, 1998; 2010; Bogaert & Blanchard, 1996; Bogaert & Liu, 2013; cf. Bogaert & Friesen, 2002; Martin & Nguyen, 2004). The results have been less consistent for studies in women than for studies in men (e.g., Bogaert, 2010; Bogaert & Liu, 2013; Singh, Vidaurri, Zambarano, & Dabbs, 1999). Most recently, Skorska and Bogaert (2016) found an objective height difference between gay men and heterosexual men, such that gay men were shorter than heterosexual men, which is an important finding given that several of the early studies used self-reported height (cf. Blanchard et al., 1995; Martin & Nguyen, 2004). Skorska and Bogaert (2016) did not find an objective height difference between lesbian women and heterosexual women, although means were in the predicted direction (i.e., lesbian women slightly taller than heterosexual women). The effect sizes within men are small, such that gay men were approximately 1cm to 2cm shorter than heterosexual men, which translates into a Cohen's *d* with a range of 0.03 to 0.27, depending on the study. In women, the effect is smaller or there is no group difference, depending on the study.

A prenatal hormone theory has been the most popular explanation for the height differences found between gay men and heterosexual men and between lesbian women and heterosexual women (when the effects have been found in women). This theory proposes that typical levels of hormones (e.g., testosterone) have been altered in prenatal sexual development (e.g., lowered in male fetuses; raised in female fetuses), and that this atypical exposure to prenatal hormones via action on the brain ultimately predisposes an individual to a same-sex orientation later on in life (Balthazart, 2011; Bao & Swaab, 2011; Becker et al., 2005; Ellis & Ames, 1987; Hines, 2011; Ngun et al., 2011; Skorska & Bogaert, 2016). Given that men are, on average, taller than women (Frayer & Wolpoff, 1985; Gray & Wolfe, 1980; Martin & Nguyen, 2004), and prenatal hormones partly underlie this difference (Chernausek, Backeljauw, Frane, Kuntze, & Underwood, 2007; Clarke & Khosla, 2009; Cutler, 1997; Garnett, Hogler, Blades, Baur, Peat, Lee, & Cowell, 2004; Geary, Pringle, Rodeck, Kingdom, & Hindmarsh, 2003; Jansson, Ekberg, Isaksson, Mode, & Gustafsson, 1985; Lichanska & Waters, 2008; Martin & Nguyen, 2004; Walker, Van Wyk, & Underwood, 1992), when height is shifted in the female-like way in gay men (i.e., shorter) and in the male-like way in lesbian women (i.e., taller), this pattern of results suggests that variations in prenatal hormones may partly underlie the development of sexual orientation, and its link to height. Variations in prenatal hormones, however, are only one plausible explanation.

An alternative plausible explanation of the height difference between, for example, gay and heterosexual men, concerns interactions between the environment and biology. Gay men are more likely, on average, to experience more stress, including psychosocial stressors, than heterosexual men (e.g., Collier, van Beusekom, Bos, & Sandfort, 2013; Fournier, Austin, Samples, Goodenow, Wylie, & Corliss, 2009; Hatzenbuehler, McLaughlin, & Xuan, 2012; Jabson, Farmer, & Bowen, 2014; Johns, Zimmerman, & Bauermeister, 2013; Lindley, Walsemann, & Carter, 2012; Rosario, Reisner, Corliss, Wypij, Frazier, & Austin, 2014). For example, gay adolescents may experience some emotional stress because of questioning their sexuality, or heightened alienation from their families or peers due to their sexual minority status (Collier et al., 2013; Johns et al., 2013; Rosario et al., 2014). Greater stress related to social/emotional development has been associated with decreased height (Johnson & Gunnar, 2011; Martorell, 2010; Surkan, Ettinger, Hock, Ahmed, Strobino, & Minkovitz, 2014). Thus, it is also possible that a difference in height between gay and hetereosexual men may be explained by biological factors associated with environmental/psychosocial stressors that affect the development of height. If true, a height difference may say less about the development of sexual orientation per se, and more about how stress affects the development of stature.

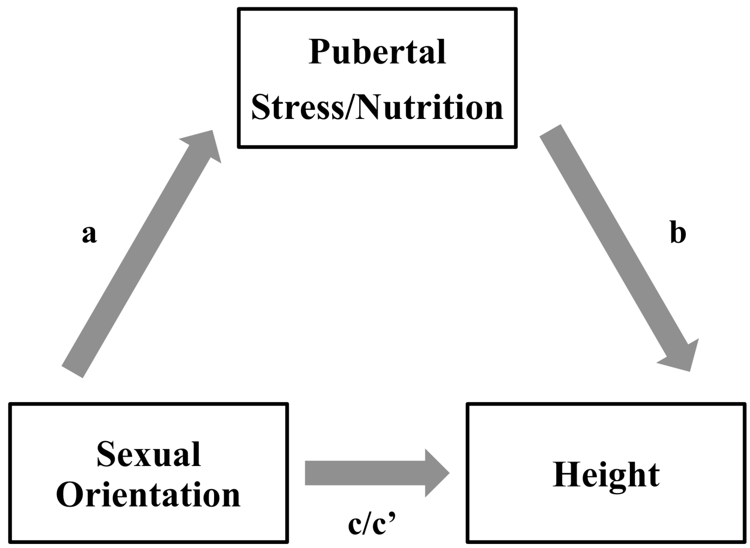
A second alternative explanation of the height difference between gay and heterosexual men involves nutrition. The nutrition explanation is, arguably, less plausible than a stress effect because, although there is an association between height and nutrition (e.g., de Beer, 2012), the association between sexual orientation and nutritional intake or eating habits has been less extensively studied, and the studies conducted to date do not suggest an association between sexual orientation and nutrition/eating habits (Boehmer & Bowen, 2009; Boehmer, Miao, Linkletter, & Clark, 2012; Deputy & Boehmer, 2010; Neumark-Sztainer, Story, Resnick, & Blum, 1998). Nevertheless, given the association between height and nutrition, and given that the association between sexual orientation and nutrition has been less extensively studied, there is still some rationale to test it as an alternative explanation to the prenatal hormone explanation, although it is more exploratory.

Thus, it is important to test the various competing and plausible explanations of the association between sexual orientation and height, to begin to understand what is occurring. In the current study, the first goal was to test, in a national probability sample of adolescents and young adults, whether there was a difference in adult objective height between gay men and heterosexual men, and between lesbian women and heterosexual women. We predicted that gay men would be shorter, on average, than heterosexual men, and that lesbian women would be taller, on average, than heterosexual women. If there was a height difference, the next goal was to examine whether stress and/or nutrition during adolescence mediate the relationship between sexual orientation and height in accordance with Figure 2.1.[3] Our prediction was that there might be partial mediation of the sexual orientation and height relationship with stress-related variables, given that sexual orientation has been related to stress, and height has been related to stress. We predicted that nutrition would not mediate the relationship between sexual orientation and height, given the lack of support in the current literature for the association between sexual orientation and nutrition.

Waves I and IV of the National Longitudinal Study of Adolescent Health (Add Health) were used to test these predictions (Harris, 2009). The aim of the Add Health study was to gather data regarding the health of a cohort of American adolescents in grades seven to twelve (Harris et al., 2009). The sample is a nationally representative sample of adolescents and young adults that has been followed from 1994 until 2008, through four waves of data. Specifically, at Wave I, participants were approximately 11 to 18 years of age. At Wave IV the majority of participants were between 24 and 34 years of age. Thus, at Wave I, a portion of the sample was, on average, either in the early stages of puberty or beginning puberty. Puberty is an important developmental stage to consider,

[3] Our primary goal with respect to mediation was to examine stress as a mediator. Nutrition was included because variables measuring some aspects of nutrition were available in the data set used here and there was some (weak) rationale for examining it as a mediator.

**Figure 2.1.** Path diagram for the mediation model tested in the paper.



because it coincides with hormonal surges known to influence physical development in boys and girls, including height. Thus, to investigate whether stress and/or nutrition explain the relationship between sexual orientation and height, the mediation model shown in Figure 2.1 was tested, within each sex.[4]

## 2.2 Method

### 2.2.1 Participants

At Wave I, 20,745 adolescents were interviewed at home from a larger sample of 90,118 adolescents who were interviewed at various high schools and feeder schools of some of the high schools (see Procedure section for further details). At Wave IV 15,701 of the original Wave I respondents were re-interviewed at home. We used a sub-sample of 14,800 participants who had a Wave IV cross-sectional sample weight (Chen & Chantala, 2014; Savin-Williams & Joyner, 2014a), and further reduced the sample to 14,786 to remove individuals who were marked with an inconsistent sex between Waves I and IV ($n$ = 14). Of the 14,786 participants, 6,924 were men and 7,862 were women. The mean age of the sample at Wave I was 15.48 years ($SE$ = 0.12, $n$ = 14778) and at Wave IV was 28.38 years ($SE$ = 0.12, $n$ = 14,786).

Race/ethnicity was self-reported by participants at Wave I, and participants could choose more than one of the following categories: “White” ($n$ = 9,433), “Black or African American” ($n$ = 3,311), “American Indian or Native American” ($n$ = 500), “Asian or Pacific Islander” ($n$ = 1,019) or “Other” ($n$ = 1,295). At Wave IV participants self-

[4] The data in this study could be tested using a moderation model (e.g., stress moderating the relationship between sexual orientation and height); however, moderation is not the focus of this study, and asks a different question (of “when”) than what we are interested in answering in the current study, which is “why.”

reported the highest level of education they had completed to date. Participants chose either “eighth grade or less” (*n* = 52), “some high school” (*n* = 1,090), “high school graduate” (*n* = 2,393), “some vocational/technical training (after high school)” (*n* = 523), “completed vocational/technical training (after high school)” (*n* = 936), “some college” (*n* = 5,056), “completed college (bachelor’s degree)” (*n* = 2,909), “some graduate school” (*n* = 556), “completed a master’s degree” (*n* = 738), “some graduate training beyond a master’s degree” (*n* = 140), “completed a doctoral degree” (*n* = 109), “some post baccalaureate professional education (e.g., law school, med school, nurse)” (*n* = 100), “completed post baccalaureate professional education (e.g., law school, med school, nurse)” (*n* = 180). Codebooks for the Add Health data are available online (“Questionnaire Codebooks for Waves I, II, III and IV”, n.d.).

### 2.2.2 Measures

Only the measures of interest to the current study are described below. Any responses in which the participant selected “refused,” “don’t know,” “not applicable” or “legitimate skip” were coded as missing data.

*Sex (Waves I and IV)*

Biological sex was self-reported by the Add Health interviewers as either male or female. As noted previously, sex that was consistent across Waves I and IV was used. In some cases, only Wave I sex was available and this was taken to be the correct measure of sex.

*Race/Ethnicity (Wave I)*

The race/ethnicity variable was dichotomized as White (coded 0; *n* = 8,877) compared to non-White (coded 1; *n* = 5,884) ethnicities (as in Skorska & Bogaert, 2016).

Participants could choose more than one category for their race/ethnicity. Those who selected only the White category were coded as 0, and those who selected any combination of other ethnicities were coded as 1.

*Education (Wave IV)*

The education variable was dichotomized to compare those who completed at least some university/college education (coded 1; *n* = 9,788) to those who did not complete any university/college education (coded 0; *n* = 4,994) (as in Skorska & Bogaert, 2016). Specifically, those who indicated they completed "eighth grade or less," completed "some high school," were a "high school graduate," completed "some vocational/technical training (after high school)," or "completed vocational/technical training (after high school)" were coded 0 and all other participants who answered the education question were coded 1.

*Sexual orientation (Wave IV)*

At Wave IV, participants were asked about their sexual orientation identity via the following statement, "Please choose the description that best fits how you think about yourself." The response options were: "100% heterosexual (straight)" (*n* = 12,679), "mostly heterosexual (straight), but somewhat attracted to people of your own sex" (*n* = 1,429), "bisexual that is, attracted to men and women equally" (*n* = 229), "mostly homosexual (gay), but somewhat attracted to people of the opposite sex" (*n* = 123), "100% homosexual (gay)" (*n* = 201), and "not sexually attracted to either males or females" (*n* = 62). Responses to the "not sexually attracted to either males or females" option were coded as missing data for the current study.

Sexual orientation identity at Wave IV was used as the sexual orientation measure in the current study given the potential problems identified by Savin-Williams and Joyner (2014a) with using measures of romantic attraction completed by participants at Wave I. Specifically, there seems to be a proportion of boys who indicated that they were same-sex romantically attracted or both-sex romantically attracted at Waves I and II, but at Waves III or IV many of them reported they were other-sex romantically attracted. Savin-Williams and Joyner (2014a) indicate that this was likely due to a misunderstanding of the romantic attraction question or that these boys were jokesters who dishonestly reported their sexual orientation. Although other interpretations exist (Katz-Wise, Calzo, Li, & Pollitt, 2015; Li, Katz-Wise, & Calzo, 2014; cf. Savin-Williams & Joyner, 2014a, 2014b), given that it is difficult to determine the exact reasons for the change to an other-sex orientation and that a change in that direction seems to be unlikely, Savin-Williams and Joyner (2014a) advise to use Wave III and/or IV sexual orientation identity data only as the measure of sexual orientation. Thus, we are following their recommendation and using Wave IV sexual orientation identity as the measure of sexual orientation.

Based on Skorska and Bogaert (2016), the main groups of interest were the exclusively heterosexual individuals (coded 0; $n_{men}$ = 6,412; $n_{women}$ = 6,267) compared to the exclusively gay/lesbian individuals (coded 1; $n_{men}$ = 126; $n_{women}$ = 75). Also, as in Skorska and Bogaert (2016), results from three other groupings were of interest: predominant heterosexual (coded 0; $n_{men}$ = 6,640; $n_{women}$ = 7,468) versus other (coded 1; $n_{men}$ = 228; $n_{women}$ = 325) sexual orientation; predominant gay/lesbian (coded 0; $n_{men}$ =182; $n_{women}$ = 142) versus bisexual (coded 1; $n_{men}$ = 46; $n_{women}$ = 183); and predominant heterosexual (coded 0) versus bisexual (coded 1). Predominant heterosexuals were those who selected either “100% heterosexual (straight)” or “mostly heterosexual (straight)”; predominant gay/lesbian were those who selected either “100% homosexual (gay)” or “mostly homosexual (gay)”; others were those who selected “bisexual,” “mostly homosexual (gay)”, or “100% homosexual (gay)”; and bisexuals were those who selected “bisexual.”

*Height (Wave IV)*

Wave IV height (cm) was used ($M$ = 170.72, $SE$ = .20, $n$ = 14660). Height was objectively measured at Wave IV by a trained interviewer, to the nearest 0.5 cm, of those participants who were capable of standing on their own. For details about how height was measured see Entzel et al. (2009).

*Nutrition (Wave I)*

At Wave I, participants answered several questions related to nutrition, which provided a total of 15 variables. See Appendix B for questions and response options for all nutrition variables. See Table 2.1 for frequencies for each nutrition variable. Participants were asked about what they usually had for breakfast across ten items (e.g., milk, cereal, eggs). For each of the 10 items, a variable was created if they ate the item (coded 1) or did not eat the item (coded 0). Also, participants were asked about the food they ate yesterday across five items (e.g., vegetables, dairy products). For each of the five questions, a dichotomous variable was created to represent whether they ate the item at least once (coded 1) or did not eat the item (coded 0).

*Stress-related variables: Theoretically relevant variables (Wave I)*

Stress can be defined as “the non-specific mental or somatic result of any demand upon the body” (Selye, 1982, as cited in Poole, Matheson, & Cox, 2008, p. 55); however,

Table 2.1. Frequencies for nutrition variables in the entire sample.

| Variable | *n* no | *n* yes | *n* total |
|---|---|---|---|
| Breakfast: Milk | 6480 | 8297 | 14777 |
| Breakfast: Coffee, tea | 13874 | 903 | 14777 |
| Breakfast: Cereal | 7388 | 7389 | 14777 |
| Breakfast: Fruit, juice | 9815 | 4962 | 14777 |
| Breakfast: Eggs | 12324 | 2453 | 14777 |
| Breakfast: Meat | 13135 | 1642 | 14777 |
| Breakfast: Snack food | 13710 | 1067 | 14777 |
| Breakfast: Breads | 9480 | 5297 | 14777 |
| Breakfast: Other | 12978 | 1799 | 14777 |
| Breakfast: Nothing | 11730 | 3047 | 14777 |
| Ate yesterday: Dairy | 2527 | 12247 | 14774 |
| Ate yesterday: Fruit, juice | 3109 | 11666 | 14775 |
| Ate yesterday: Vegetables | 4839 | 9931 | 14770 |
| Ate yesterday: Bread, pasta | 1216 | 13559 | 14775 |
| Ate yesterday: Pastries | 6722 | 8054 | 14776 |

the construct of stress is difficult to define because it is a multidimensional construct, and because stress is experienced subjectively. Nevertheless, stress is operationalized in many ways in the research literature. Many of the operationalizations focus on the outcomes of stress (i.e., the "mental or somatic result" in the definition), the person's perceptions of how stressed they feel, or measurements of cortisol, a key hormone involved in the stress response.

In the current study, we wanted to capture stress as broadly as possible because of potential concerns that we may have missed an important stress-related mediator of the relationship between sexual orientation and height. We used operationalizations of stress based on what has been previously used in studies using Wave I of the Add Health data, in studies conducted both on sexual minority youth and in studies not related to sexual orientation. We also attempted to identify stress-related variables that would be relevant to the association between childhood environment and height in children. These variables should be related to an environment that is deficient in psychosocial development and maternal support (Gohlke, Frazer, & Stanhope, 2004; Johnson & Gunnar, 2011; Surkan, et al., 2014). Given these ways of measuring stress, 24 variables in 19 categories of variables were identified and computed to represent stress or the outcomes of stress in Wave I of the Add Health data. We have grouped the stress variables based on whether they are theoretically relevant (i.e., social emotional stress-related variables) versus more exploratory stress-related variables. The variables that are of theoretical interest (17 variables, 13 categories) are outlined next. In the following section, the exploratory stress-related variables (seven variables, six categories) are outlined. See Table 2.2 for descriptive statistics for all continuous stress-related variables. See Appendix B for the

Table 2.2. Descriptive statistics for each of the continuous stress-related variables in the entire sample.

| Variable | *M* | *SE* | *95% CI* | Range[a] | *n* |
|---|---|---|---|---|---|
| Exploratory Stress-Related Variables | | | | | |
| Self-rated health | 2.13 | 0.01 | 2.10–2.16 | 1–5 | 14776 |
| Health stress | 0.79 | 0.01 | 0.78–0.81 | 0–4 | 14776 |
| Parental control | 0.27 | 0.01 | 0.25–0.28 | 0–1 | 14507 |
| Theoretically Relevant Stress-Related Variables | | | | | |
| Depressive symptoms | 0.58 | 0.01 | 0.56–0.59 | 0–3 | 14756 |
| SN: In degree | 4.58 | 0.12 | 4.35–4.82 | 0–32 | 10667 |
| SN: Reach | 60.52 | 2.69 | 55.19–65.86 | 0–270 | 10667 |
| SN: Out degree | 4.60 | 0.10 | 4.41–4.80 | 0–10 | 10667 |
| SN: Bonacich centrality | 0.82 | 0.01 | 0.80–0.84 | 0–4.29 | 10667 |
| Perceived social support | 1.97 | 0.01 | 1.94–1.99 | 1–5 | 14697 |
| School belonging | 2.44 | 0.02 | 2.40–2.48 | 1–5 | 14503 |
| School stress | 1.06 | 0.01 | 1.04–1.09 | 0–4 | 14511 |
| Self-esteem | 1.89 | 0.01 | 1.86–1.91 | 1–5 | 14749 |
| Parent rejection | 1.91 | 0.01 | 1.90–1.93 | 1–5 | 12816 |
| Want to run away | 2.16 | 0.03 | 2.10–2.23 | 1–5 | 14564 |
| Child-mother connectedness | 1.66 | 0.01 | 1.64–1.68 | 1–5 | 13946 |
| Child-father connectedness | 1.76 | 0.02 | 1.73–1.79 | 1–5 | 10495 |

*Note*. *M* = mean, *SE* = standard error, *95% CI* = 95% confidence interval of the mean, SN = social network.

[a] Ranges are theoretical ranges, with the exception of the social network variables. The ranges for the social network variables are response-specific ranges based on friendship nominations.

specific questions and response options for each stress-related variable. Across all variables, all necessary items were reverse coded, and, when an average was computed, it was computed for those who answered approximately 80% of the relevant items. Cronbach's α values were not computed using Complex Samples (see Statistical Analyses section) because this analysis is not available with the Complex Samples function in SPSS. Instead, they were computed on the unweighted data and thus should not be generalized beyond the unweighted sample.

**Depressive symptoms**. A 19-item scale (e.g., "You were bothered by things that usually don't bother you") similar to the Center for Epidemiologic Studies Depression Scale (CES-D) was used (e.g., Adkins, Daw, McClay, & Oord, 2012; Galliher, Rostosky, & Hughes, 2004; Georgiades, Boyle, & Fife, 2013; Hatzenbuehler et al., 2012; Heard, Gorman, & Kapinus, 2008; Jager & Davis-Kean, 2011; Nooney, 2005; Schreck, Burek, Stewart, & Miller, 2007; Wight, Botticello, & Aneshensel, 2006). An average was computed such that higher scores represent greater reporting of depressive symptoms (*Cronbach's* $\alpha = .86$).

**Social network variables**. Hatzenbuehler et al. (2012) utilized four variables, which tap into social network composition, that were constructed by Add Health statisticians and are available within the Add Health data. Participants were asked to name their five best male and five best female friends from both inside and outside their school. The in-degree variable represents the number of students in the school who nominated a participant as their friend. The out-degree variable represents the number of students in the school that were nominated by a participant as their friend. The reach variable is a measure of the degree of connectedness within the social network of the participant, and represents the total number of students the participant can reach in three steps within the participant's friendship network. Bonacich's centrality (β parameter) is a measure of social status and represents a participant's centrality in their peer network. For all four measures of social networks, higher scores indicate a greater social network (e.g., greater social status). See the "Network Variables" codebook available online for more details about the computation of these variables ("Questionnaire Codebooks for Waves I, II, III and IV", n.d.).

**Violent victimization**. Based on Schreck et al. (2007) and Hatzenbuehler et al. (2012), four items were used to create a dichotomous measure of whether the participant was violently victimized (coded 1; $n$ = 2,923) or not (coded 0; $n$ = 11,781). If participants answered that they had been in at least one of these four experiences (e.g., they were jumped), they were coded as 1; otherwise, they were coded 0.

**School belonging**. The degree with which the participant felt they belonged at school was assessed using six items (e.g., Galliher et al., 2004; Georgiades et al., 2013; Wickrama, Noh, & Elder, 2009). An average was computed such that higher scores represent less school belonging (*Cronbach's* $\alpha$ = .72).

**School stress**. The frequency with which participants engaged in behaviours related to being stressed at school was assessed using four items (e.g., Heard et al., 2008; Nooney, 2005). An average was computed such that higher scores represent more school stress (*Cronbach's* $\alpha$ = .69).

**Perceived social support**. Seven items were used to assess the degree to which participants felt they received support from those around them (e.g., Adkins et al., 2012;

Heard et al., 2008; Nooney, 2005; Wight et al., 2006). An average was computed such that higher scores represent less perceived social support (*Cronbach's α* = .78).

**Running away from home**. Two variables were used as measures of running away from home. The first variable is the participant's response to one item about the degree to which a participant felt that they wanted to leave home. Higher numbers represent a greater want to leave home (Table 2.2). The second variable is a dichotomous variable that indicates whether the participant had ever ran away from home in the past 12 months (e.g., "1 or 2 times"; *n* = 1,209; coded 1) or "never" ran away from home in the past 12 months (*n* = 13,485; coded 0).

**Self-esteem**. Six items were used to assess self-esteem (e.g., "You like yourself just the way you are"; Galliher et al., 2004; Heard et al., 2008; Nooney, 2005). An average was computed such that higher scores represent less self-esteem (*Cronbach's α* = .85).

**Child-mother connectedness**. Seven items were used to represent the degree to which participants felt connected to their mother (e.g., Heard et al., 2008; Wickrama et al., 2009; Williams & Chapman, 2012). An average was computed such that higher scores represent less connectedness to their mother (*Cronbach's α* = .86).

**Child-father connectedness**. Five items were used to represent the degree to which participants felt connected to their father (e.g., Williams & Chapman, 2012). An average was computed such that higher scores represent less connectedness to their father (*Cronbach's α* = .89).

**Suicidal thoughts**. Participants were asked a question about whether they thought about committing suicide (e.g., Nooney, 2005). The response options were either a yes (coded 1; *n* = 1,998) or a no (coded 0; *n* = 12,660).

**Physical abuse**. At Wave IV participants answered a retrospective question about whether they had been physically abused (e.g., Slopen, McLaughlin, Dunn, & Koenen, 2013). A dichotomous measure of physical abuse was computed representing ever been physically abused (coded 1; *n* = 2,712) and never been physically abused (coded 0; *n* = 11,901).

**Parental rejection**. At Wave I, a parent of the participant (most of the time it was the mother) answered five questions (among others) about their relationship with the participant (e.g., "You just do not understand him/her"; Wickrama, O'Neal, & Oshri, 2014). An average was computed such that higher scores represent more rejection from the parent (*Cronbach's α* = .64).

*Stress-related variables: Exploratory variables (Wave I)*

**Self-rated health**. This variable is the participant's response to one item about how good they perceived their health to be (Heard et al., 2008). Higher numbers represent poorer health.

**Health stress**. Participants answered 20 (boys) or 21 (girls) items about the frequency with which they experienced certain symptoms or conditions (e.g., "a headache," "chest pains") in the past 12 months (e.g., Nooney, 2005). A "cramps during your menstrual period" item was the extra item asked for girls. An average was computed such that higher scores represent more health stress (*Cronbach's α* = .84 for 20 items; *Cronbach's α* = .85 for 21 items).

**Parental control**. Participants answered seven items related to whether or not parents controlled the participant (e.g., Heard et al., 2008). An average was computed such that higher scores represent more parental control (*Cronbach's α* = .63).

**Parent disability**. Participants answered two questions about the physical disability (i.e., mental or physical handicap) of their parents who currently live with them (i.e., could be biological, adoptive parents) (e.g., Williams & Chapman, 2012). Responses were "yes" (coded 1; $n_{mother}$ = 642; $n_{father}$ = 654) or "no" (coded 0; $n_{mother}$ = 13,305; $n_{father}$ = 9,846).

**Physical disability of the participant**. Participants who answered "no" to all four questions regarding physical disability were coded as not having a physical disability (coded 0; *n* = 14,080). Participants who answered that they had at least one of the conditions were coded as having a physical disability (coded 1; *n* = 691).

**Sexual abuse**. At Wave IV participants answered a retrospective question about whether they had been sexually abused (e.g., Slopen et al., 2013). A dichotomous measure of sexual abuse was computed representing ever been sexually abused (coded 1; *n* = 751) and never been sexually abused (coded 0; *n* = 13,886).

### 2.2.3 Procedure

The Add Health study used a school-based sampling design (see Harris, 2013 for more details). Briefly, 80 high schools were selected to take part in the study, stratified by region, urban or rural location, school type (e.g., public), ethnic diversity, and size of the school. For each high school, a feeder school (e.g., a middle school) was identified and recruited. The final sample included 132 schools, with each school associated with one of 80 communities. In 1994 and 1995 (Wave I), 90,118 students at these schools completed a short 45- to 60-minute in-school questionnaire. A sub-sample of students from these schools was chosen to complete a more in-depth 1.5-hour in-home interview. In the core sample of 12,105 of the in-home students, students in each school were stratified by grade and sex, and 17 were randomly chosen from each stratum for the in-home interviews for a total of about 200 students from each pair of schools. Thus, the Wave I in-home sample is a representative sample of US adolescents in grades seven to 12. The total sample size with special supplemental subsamples of students (e.g., students with certain ethnicities) is 20,745 adolescents. School administrators and 17,670 parents of the students (mostly mothers) were also interviewed. Follow up interviews at Waves II, III, and IV were based on the Wave I in-home sample of adolescents.

At the in-home interviews at Wave I, responses were recorded on laptops (Harris, 2013). For less sensitive topics, the interviewer read the question out loud and entered the participant’s answers, known as the computer assisted personal interview (or CAPI). For more sensitive topics, the participant listened through earphones to pre-recorded questions and entered responses directly by themself, known as audio-CASI (audio-computer assisted self-interview).

At Wave IV, 15,701 of the original Wave I in-home participants were re-interviewed (Harris, 2013). A 90-minute in-home interview was conducted using CAPI and CASI. Then, interviewers took physical measurements (e.g., height), collected biological specimens (e.g., blood), and took a medications log. In terms of the response rate, Harris (2013) notes that non-response bias is trivial. It is advised to use final sampling weights to compute population estimates, in order for the sample at Wave IV to represent the population recruited at Wave I. See Appendix C for a copy of the ethics clearance certificate.

**2.2.4 Statistical Analyses**

All analyses were conducted using SPSS (version 22) Complex Samples. Complex Samples allows for the sampling strategy to be taken into account. The appropriate Wave IV cross-sectional weight, stratum variable, and cluster variable were utilized to provide correct estimates of totals, ratios, regression parameters, means, variances, standard errors, and confidence intervals (Chen & Chantala, 2014). A "with replacement" design type was specified and subpopulation variables were created and utilized for analyses in which only a subset of the sample was to be analyzed (Chen & Chantala, 2014). A common subpopulation variable that was used was sex, because all height related analyses were conducted within each sex. All analyses were run with the General Linear Model (GLM) analysis in Complex Samples. The GLM analysis provides results for a simultaneous linear regression analysis, and includes the *B*s, standard errors, and *t*-test associated with each variable that is included in each analysis. In all analyses, education and race/ethnicity were entered simultaneously in order to statistically control for these variables because of their relationship to height, and to be consistent with Skorska and Bogaert (2016). For example, Black men and women tend to be shorter than White men and women (Komlos, 2010), and Skorska and Bogaert (2016) found that White participants were taller than non-White participants. Further support for the inclusion of education and race/ethnicity is also demonstrated in Table 2.3, which indicates a significant association of education with sexual orientation and height, and a significant association of ethnicity with height within men (similar results were obtained

Table 2.3. Summary of the results of separate simultaneous linear regression analyses for the a-path (sexual orientation → stress/nutrition) and b-path (stress/nutrition → height) of the mediation model within men, as well as descriptive statistics by sexual orientation group.

| Variable | A-path: sexual orientation → stress/nutrition | | | | | | | | | B-path: stress/nutrition → height | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Regression Results* | | | *Descriptive Statistics by Sexual Orientation Group* | | | | | | | | |
| | | | | *Heterosexual Men (coded 0)* | | | *Gay Men (coded 1)* | | | | | |
| | *B* | *SE* | *t* | *M* (*SE*) or *n* no[a] | *SD* or *n* yes[b] | *95% CI* or *Weighted % yes*[c] | *M* (*SE*) or *n* no[a] | *SD* or *n* yes[b] | *95% CI* or *Weighted % yes*[c] | *B* | *SE* | *t* |
| Exploratory Stress-Related Variables | | | | | | | | | | | | |
| Self-rated health[d] | 0.08 | 0.10 | 0.80 | 2.04 (0.02) | 0.89 | 2.01–2.08 | 2.05 (0.10) | 0.90 | 1.86–2.24 | -0.05 | 0.16 | -0.33 |
| Health stress[d] | 0.09 | 0.04 | 1.95* | 0.70 (0.01) | 0.36 | 0.69–0.72 | 0.79 (0.04) | 0.37 | 0.70–0.87 | 0.08 | 0.36 | 0.23 |
| Parental control[d] | -0.01 | 0.03 | -0.52 | 0.27 (0.01) | 0.23 | 0.25–0.28 | 0.25 (0.03) | 0.24 | 0.19–0.30 | -1.32 | 0.80 | -1.66 |
| Disabled mother[f] | 0.01 | 0.02 | 0.50 | 5788 | 240 | 4.3 | 110 | 8 | 5.0 | -0.18 | 0.60 | -0.30 |
| Disabled father[f] | 0.06 | 0.05 | 1.05 | 4449 | 280 | 6.5 | 81 | 5 | 10.7 | 0.62 | 0.62 | 1.01 |
| **Physical disability of participant**[f] | **-0.03** | **0.01** | **2.89**** | **6100** | **306** | **4.1** | **124** | **2** | **1.0** | **1.48** | **0.66** | **2.23**** |
| Sexual abuse[f] | 0.03 | 0.03 | 0.85 | 6216 | 134 | 2.3 | 116 | 7 | 4.7 | 0.54 | 0.97 | 0.55 |
| Theoretically Relevant Stress-Related Variables | | | | | | | | | | | | |
| Depressive symptoms[d] | 0.07 | 0.05 | 1.48 | 0.52 (0.01) | 0.34 | 0.51–0.54 | 0.57 (0.05) | 0.37 | 0.47–0.66 | -0.30 | 0.36 | -0.83 |
| SN: In degree[e] | 1.13 | 0.78 | 1.45 | 4.35 (0.12) | 3.71 | 4.11–4.60 | 5.62 (0.84) | 4.76 | 3.97–7.28 | -0.04 | 0.05 | -0.84 |
| SN: Reach[e] | 18.10 | 6.87 | 2.63** | 57.09 (2.85) | 49.41 | 51.45–62.74 | 77.36 (7.88) | 44.53 | 61.75–92.97 | 0.00 | 0.004 | 0.72 |
| SN: Out degree[e] | 0.58 | 0.27 | 2.18** | 4.33 (0.12) | 3.17 | 4.10–4.57 | 5.07 (0.30) | 2.81 | 4.47–5.66 | 0.02 | 0.05 | 0.34 |
| SN: Bonacich centrality[e] | 0.17 | 0.06 | 2.77** | 0.78 (0.02) | 0.66 | 0.75–0.82 | 1.00 (0.07) | 0.68 | 0.87–1.13 | -0.03 | 0.28 | -0.09 |
| Perceived social support[d] | -0.03 | 0.07 | -0.41 | 1.98 (0.02) | 0.58 | 1.95–2.01 | 1.93 (0.07) | 0.53 | 1.79–2.07 | 0.48 | 0.22 | 2.20** |
| Violent | -0.22 | 0.02 | -9.27** | 4493 | 1879 | 28.6 | 112 | 14 | 5.0 | 0.14 | 0.28 | 0.49 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| victimization[f] | | | | | | | | | | | | |
| School belonging[d] | 0.09 | 0.08 | 1.09 | 2.41 (0.02) | 0.68 | 2.37–2.45 | 2.47 (0.08) | 0.71 | 2.30–2.64 | 0.29 | 0.19 | 1.57 |
| School stress[d] | -0.00 | 0.09 | -0.01 | 1.15 (0.02) | 0.74 | 1.12–1.18 | 1.10 (0.09) | 0.72 | 0.93–1.27 | 0.37 | 0.18 | 2.11** |
| Self-esteem[d] | 0.10 | 0.08 | 1.23 | 1.79 (0.01) | 0.55 | 1.76–1.81 | 1.86 (0.08) | 0.60 | 1.70–2.02 | -0.07 | 0.22 | -0.31 |
| Parental rejection[d] | -0.02 | 0.10 | -0.22 | 1.91 (0.01) | 0.55 | 1.88–1.93 | 1.85 (0.10) | 0.65 | 1.66–2.05 | 0.68 | 0.27 | 2.54** |
| Suicidal thoughts[f] | 0.09 | 0.04 | 1.93* | 5728 | 619 | 10.1 | 97 | 28 | 18.1 | -0.13 | 0.45 | -0.29 |
| Want to run away[d] | 0.03 | 0.15 | 0.23 | 2.11 (0.04) | 1.21 | 2.05–2.18 | 2.17 (0.14) | 1.33 | 1.89–2.44 | 0.20 | 0.11 | 1.84* |
| Ever ran away[f] | 0.00 | 0.03 | 0.03 | 5936 | 428 | 7.2 | 116 | 10 | 6.3 | 1.06 | 0.54 | 1.96* |
| Child-mother connectedness[d] | -0.03 | 0.08 | -0.42 | 1.61 (0.01) | 0.55 | 1.58–1.63 | 1.56 (0.08) | 0.65 | 1.41–1.72 | -0.04 | 0.27 | -0.16 |
| Child-father connectedness[d] | 0.21 | 0.14 | 1.48 | 1.68 (0.02) | 0.69 | 1.64–1.72 | 1.87 (0.14) | 0.82 | 1.60–2.15 | 0.21 | 0.18 | 1.15 |
| Physical abuse[f] | 0.02 | 0.05 | 0.34 | 5144 | 1182 | 17.4 | 99 | 26 | 18.9 | 0.43 | 0.28 | 1.54 |
| Nutrition Variables | | | | | | | | | | | | |
| Br.: Milk[f] | -0.08 | 0.06 | -1.42 | 2347 | 4062 | 64.3 | 51 | 74 | 57.1 | -0.07 | 0.28 | -0.25 |
| Br.: Coffee, tea[f] | 0.01 | 0.03 | 0.34 | 5997 | 412 | 6.6 | 118 | 7 | 7.1 | -0.45 | 0.57 | -0.79 |
| Br.: Cereal[f] | -0.06 | 0.06 | -0.94 | 2822 | 3587 | 57.1 | 63 | 62 | 52.9 | 0.03 | 0.30 | 0.10 |
| Br.: Fruit, juice[f] | 0.06 | 0.06 | 1.04 | 4222 | 2187 | 34.0 | 82 | 43 | 42.7 | -0.34 | 0.26 | -1.30 |
| Br.: Eggs[f] | -0.09 | 0.04 | -2.56** | 5044 | 1365 | 21.0 | 106 | 19 | 11.0 | -0.22 | 0.33 | -0.67 |
| Br.: Meat[f] | -0.02 | 0.05 | -0.41 | 5541 | 868 | 13.5 | 113 | 12 | 11.5 | 0.89 | 0.38 | 2.38** |
| Br.: Snack food[f] | 0.00 | 0.03 | 0.02 | 5940 | 469 | 7.0 | 120 | 5 | 6.9 | 0.47 | 0.43 | 1.09 |
| Br.: Breads[f] | -0.06 | 0.06 | -1.11 | 4008 | 2401 | 36.5 | 85 | 40 | 31.7 | -0.04 | 0.25 | -0.18 |
| Br.: Other[f] | 0.04 | 0.05 | 0.94 | 5603 | 806 | 12.6 | 108 | 17 | 17.0 | -0.26 | 0.45 | -0.58 |
| Br.: Nothing[f] | 0.00 | 0.06 | 0.01 | 5342 | 1067 | 16.2 | 102 | 23 | 15.8 | 0.11 | 0.31 | 0.34 |
| AY: Dairy[f] | -0.30 | 0.04 | -0.69 | 853 | 5554 | 87.8 | 16 | 110 | 85.8 | 0.19 | 0.46 | 0.42 |
| AY: Fruit, juice[f] | -0.02 | 0.05 | -0.31 | 1322 | 5086 | 77.6 | 28 | 98 | 78.9 | 0.51 | 0.29 | 1.78* |
| AY: Vegetables[f] | -0.07 | 0.07 | -0.95 | 2028 | 4379 | 68.8 | 35 | 90 | 64.5 | 0.30 | 0.31 | 0.95 |
| AY: Bread, pasta[f] | -0.05 | 0.05 | -1.01 | 458 | 5949 | 93.4 | 6 | 120 | 89.2 | 0.56 | 0.45 | 1.26 |
| AY: Pastries[f] | -0.07 | 0.08 | -0.89 | 2697 | 3711 | 58.3 | 54 | 72 | 52.2 | 0.33 | 0.29 | 1.16 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Control Variables | | | | | | | | | | | | |
| Race/Ethnicity | 0.06 | 0.06 | 1.05 | 3897 | 2507 | 29.7 | 73 | 52 | 35.8 | -2.29 | 0.38 | -6.09** |
| Education | 0.23 | 0.05 | 4.48** | 3897 | 2514 | 42.2 | 101 | 25 | 18.8 | 1.45 | 0.32 | 4.57** |
| Age | 0.14 | 0.22 | 0.66 | 28.47 (0.12) | 1.77 | 28.23–28.72 | 28.62 (0.23) | 1.61 | 28.16–29.08 | -0.03 | 0.09 | -0.40 |

*Note*. SN = social network; Br. = breakfast; AY = ate yesterday. Shaded columns include a-path related analyses and descriptive statistics. Right-most non-shaded columns include b-path related analyses. Analyses with the stress-related and nutrition variables statistically controlled for education and race/ethnicity. Lines in bold represent results where both the a-path and b-path are significant or marginally significant, $^{**}p < .05$, $^{*}p < .08$, otherwise $p > .09$ (i.e., not significant).

[a] This column shows means and standard errors for continuous variables *or* the number of participants who responded “no” to a dichotomous variable. For race/ethnicity, it is the number of participants who were categorized as having a White race/ethnicity (coded 0); for education, it is the number who were categorized as having a university education (coded 1).

[b] This column shows the sample standard deviation for continuous variables *or* the number of participants who responded “yes” to a dichotomous variable. For race/ethnicity, it is the number of participants who were categorized as having a non-White race/ethnicity (coded 1); for education, it is the number who were categorized as having a non-university education (coded 0). The sample standard deviation was calculated for the sample of $n$ = 14,786 participants who have a Wave IV sample weight, but without taking into account the sampling design of the data. Thus the sample standard deviation cannot be generalized to the population.

[c] This column shows the 95% confidence interval (CI) around the mean for continuous variables *or* the % of yes respondents after calculation of the population estimates for the no and yes responses for dichotomous variables. Thus, the weighted % yes will not always reflect the unweighted counts in $n$ no and $n$ yes.

[d] Higher scores indicate more stress. For example, higher scores on the child-mother and child-father connectedness variables indicate less connectedness.

[e] Higher scores indicate less stress. For example, higher scores indicate more friendship nominations.

[f] Coded as either a 0 (“no”) or 1 (“yes”).

in women but are not shown). Age at Wave IV was unrelated to sexual orientation and to height (see bottom of Table 2.3), and thus it was not entered in any analyses.

In the mediation model shown in Figure 2.1, there are three paths in the model that need to be tested in order to determine whether mediation occurs (Baron & Kenny, 1986). First, it must be established that a c-path exists between the two main variables of interest, sexual orientation and height (i.e., dependent variable [DV] = height, independent variable [IV] = sexual orientation). Then, the a-path from sexual orientation to stress/nutrition must be demonstrated to exist (i.e., DV = stress/nutrition, IV = sexual orientation). Next, the b-path from stress/nutrition to height must be demonstrated to exist (i.e., DV = height, IV = stress/nutrition). Finally, any stress/nutrition variables in which both an a-path and a b-path exist can be tested to determine whether their inclusion in the model with both sexual orientation and height eliminates or reduces the association between sexual orientation and height. To do this, the potential stress/nutrition mediator variable is included in the model simultaneously with sexual orientation (DV = height). If the association between sexual orientation and height is eliminated, there is some evidence of mediation. If the association between sexual orientation and height is reduced, there may be some evidence of partial mediation. The Sobel test can be used to indicate whether mediation exists or not (i.e., whether the reduction in the c-path is significant after inclusion of the mediator in the model). This was the general analysis strategy utilized in the current paper.

Each stress and nutrition variable was tested in a separate simultaneous linear regression analysis in order to establish whether the a-path and the b-path existed. Separate analyses were conducted in order to reduce likely multicollinearity issues with the stress and nutrition variables. We did not have specific predictions for which stress and nutrition variables would be involved, and thus, the results should be interpreted with caution given the number of tests conducted. Then, any stress/nutrition variables that showed a significant or marginally significant difference between gay/lesbian and heterosexual individuals (i.e., a-path) *and* showed a significant or marginally significant association with height (i.e., b-path) were tested for mediation.

In addition to the mediation analyses, we were interested in examining the association between sexual orientation and height, statistically controlling for any stress/nutrition variables that were associated with height (i.e., significant or marginally significant b-path only). We conducted a linear regression analysis with sexual orientation and the relevant stress/nutrition variables as IVs and height as DV to determine whether the sexual orientation and height association holds over and above the association of the stress/nutrition variables and height.

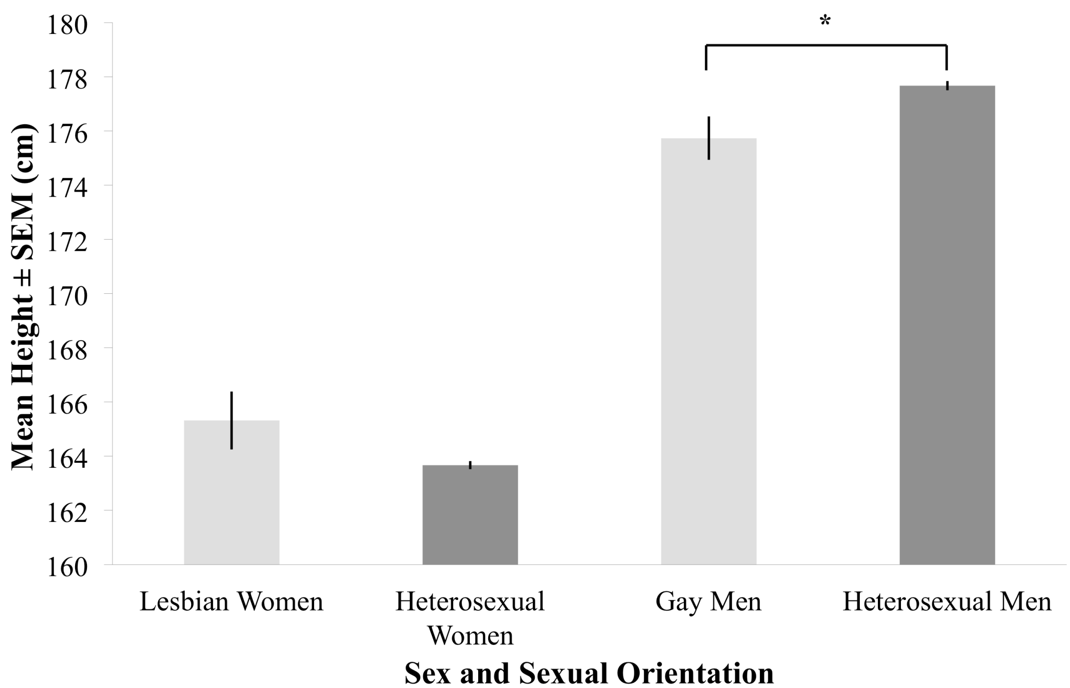
## 2.3 Results

### 2.3.1 C-Path Analyses

Within the subpopulation of women, sexual orientation, race/ethnicity, and education accounted for 2.5% of the variance in height. Race/ethnicity and education were significant predictors, such that White women and women with some university/college education were taller than non-White women and women with no university/college education. Sexual orientation was not a significant predictor, $B = 1.65$, $SE = 1.08$, *95% confidence interval (CI)* = -0.49 to +3.78, $t(128) = 1.52$, $p = .131$. Thus, exclusively lesbian women ($M = 165.32$, $SE = 1.07$) were slightly taller than exclusively heterosexual women (*M* = 163.67, *SE* = 0.15), but the difference was not statistically significant (Figure 2.2). Results were similar when examining predominantly heterosexual women compared to bisexual/predominantly lesbian women, *B* = 0.86, *SE* = 0.55, *95% CI* = -0.23 to +1.94, $t(128) = 1.57$, $p = .120$. Although none of the height differences were statistically significant, bisexual women (*M* = 164.30, *SE* = 0.75) seemed to be more similar in average height to predominantly lesbian women (*M* = 164.57, *SE* = 0.71; *B* = -0.27, *SE* = 1.06, *95% CI* = -2.38 to 1.84, $t(119) = -0.25$, $p = .800$) than to predominantly heterosexual women (*M* = 163.73, *SE* = 0.14; *B* = 0.78, *SE* = 0.76, *95% CI* = -0.73 to +2.28, $t(128) = 1.02$, $p = .311$). Thus, some very small differences were found within women, but overall, there were no statistically significant differences in height between women with a same-sex orientation identity and women with an other-sex orientation identity.

Within the subpopulation of men, sexual orientation, race/ethnicity and education accounted for 2.5% of the variance in height. Race/ethnicity and education were significant predictors, such that White men and men with some university/college education were taller than non-White men, and men with no university/college education. Most importantly, sexual orientation was a significant predictor, *B* = -1.94, *SE* = 0.79, *95% CI* = -3.51 to -0.37, $t(128) = -2.44$, $p = .016$. Thus, exclusively gay men (*M* = 175.73, *SE* = 0.80) were significantly shorter than exclusively heterosexual men (*M* = 177.67, *SE* = 0.17) (Figure 2.2). Results were similar when examining predominantly heterosexual men compared to bisexual/predominantly gay men, *B* = -1.39, *SE* = 0.63, *95% CI* = -2.64 to -0.14, $t(128) = -2.20$, $p = .030$. Bisexual men (*M* = 176.39, *SE* = 0.96) seemed to be more similar in average height to predominantly

**Figure 2.2.** Approximate average height (cm), by sex and exclusive sexual orientation identity, statistically controlling for education and ethnicity. * indicates the difference was significant at $p < .05$.



gay men (*M* = 176.45, *SE* = 0.77; *B* = -0.06, *SE* = 1.26, *95% CI* = -2.56 to +2.43, *t*(119) = -0.05, *p* = .961) than to predominantly heterosexual men (*M* = 177.66, *SE* = 0.18; *B* = -1.39, *SE* = 0.85, *95% CI* = -3.06 to +0.28, *t*(128) = -1.64, *p* = .103), although none of these height differences were statistically significant. Thus, men with a large degree of same-sex orientation identity were shorter, on average, than men with a predominantly other-sex orientation identity.

**2.3.2 A-Path Analyses**

A-path and b-path analyses were only conducted in men since a statistically significant association between sexual orientation and height (i.e., c-path) was found only within men. The results of both a-path and b-path analyses are summarized in Table 2.3, with a-path results in the shaded columns. An exclusively gay sexual orientation was associated with greater health stress, not having a physical disability, more nominations by friends within the participant's school, more total number of students they could reach in three steps within their peer network, a greater centrality in their peer network, no violent victimization, presence of suicidal thoughts, and not eating eggs for breakfast, compared with exclusively heterosexual men. The predicted negative association (i.e., stress is greater in gay men) only occurred with the health stress and suicidal thoughts variables, whereas gay men experienced less stress compared with heterosexual men on physical disability, social network, and violent victimization variables.[5] See Appendix D for descriptive statistics for all measures within lesbian women and heterosexual women.

[5] For all categorical stress and nutrition variables, logistic regression analyses were also run. Results were the same with the following exceptions: physical disability of the participant was not significant, suicidal thoughts was significant, and eating eggs at breakfast was now marginally significant. We chose to keep the GLM analyses within the paper so that a-path, b-path, c-path, and mediation analyses all used GLM.

### 2.3.3 B-Path Analyses

Within men, taller height was associated with presence of a physical disability in the participant, less perceived social support, more school stress, more parental rejection, a greater want to run away from home, actually running away from home, eating meat for breakfast, and eating fruit or juice (Table 2.3). Again, the predicted negative association (i.e., greater stress is associated with being shorter) was not found with any of these variables. Indeed, the opposite positive association occurred, such that greater stress was associated with being taller.

### 2.3.4 Mediation Analyses

The only stress or nutrition variable that was a candidate for mediation analyses (i.e., there was a difference between gay men and heterosexual men *and* was associated with height) was physical disability of the participant. We first note that the results are not in the expected direction. That is, a gay sexual orientation was associated with not having a physical disability, and a shorter height was associated with not having a physical disability. If physical disability of the participant mediates the relationship between sexual orientation and height in a theoretically meaningful way, then it would be expected that a gay sexual orientation should be associated with having a physical disability, and a shorter height should be associated with having a physical disability. Convergent with this logic, within men, sexual orientation was still significant ($B$ = -1.89, $SE$ = 0.80, *95% CI* = -3.47 to -0.32, $t(128) = -2.38$, $p = .019$) after entering physical disability of the participant in the model ($B$ = 1.55, $SE$ = 0.68, *95% CI* = 0.21 to 2.88, $t(128) = 2.29$, $p = .024$). Race/ethnicity and education were significant as well. The reduction in the c-path after including physical disability of the participant in the model (*a* = -0.03, $SE_a$ = 0.01, *b* = 1.55, $SE_b$ = 0.68; Preacher & Leonardelli, 2001) trended toward significance (*Sobel test statistic* = -1.81, *SE* = 0.03, *p* = .07). Given that physical disability of the participant was not a variable of theoretical interest, the a-path and b-path results were not in the expected directions, sexual orientation was still significant in the model with the mediator variable simultaneously entered into the model, and the reduction in the c-path trended toward significance, it is unlikely that physical disability of the participant mediates the relationship between sexual orientation and height, even partially.

**2.3.5 Accounting for Stress/Nutrition-Height Association Analyses**

We also examined the sexual orientation and height relationship in men controlling for significant or marginally significant b-path variables; that is, after entering any potentially confounding variables related to height (see Table 2.3 in the non-shaded right-most columns). Within men, sexual orientation was still significant (*B* = -1.83, *SE* = 0.79, *95% CI* = -3.40 to -0.26, *t*(128) = -2.31, *p* = .023) after simultaneously entering in the following variables that were associated with height (i.e., b-path variables): wanting to run away from home, actually ran away from home, school stress, perceived social support, physical disability of participant, eating meat at breakfast, and eating fruit and juice the day before (see Table 2.4 for results of the simultaneous linear regression analysis). Sexual orientation was also significant when these variables were entered within their own, separate linear regression analyses. Thus, statistically controlling for stress variables that were associated with height, exclusively gay men

Table 2.4. Results of a simultaneous linear regression analysis within men, using all b-path variables that were significant or marginally significant in Table 2.3.

| | *Height* | | | | |
|---|---|---|---|---|---|
| Variable | *B* | *SE* | *95% CI* | *t*(*df*) | *p* |
| Race/Ethnicity | -2.36 | 0.36 | -3.08 to -1.64 | -6.47(128) | < .001 |
| Education | 1.25 | 0.32 | 0.61 to 1.89 | 3.88(128) | < .001 |
| Sexual orientation | -1.83 | 0.79 | -3.40 to -0.26 | -2.31(128) | .023 |
| Physical disability of the participant | 1.41 | 0.70 | 0.02 to 2.79 | 2.01(128) | .046 |
| Want to run away | 0.09 | 0.12 | -0.15 to +0.32 | 0.72(128) | .474 |
| Actually ran away | 0.42 | 0.56 | -0.68 to +1.52 | 0.76(128) | .448 |
| School stress | 0.20 | 0.21 | -0.22 to +0.63 | 0.95(128) | .345 |
| Perceived social support | 0.35 | 0.28 | -0.21 to +0.91 | 1.24(128) | .218 |
| Breakfast: Meat | 1.05 | 0.37 | 0.32 to 1.79 | 2.83(128) | .005 |
| Ate yesterday: Fruit, juice | 0.54 | 0.31 | -0.07 to +1.16 | 1.75(128) | .082 |

*Note*. *SE* = standard error, *95% CI* = 95% confidence interval of B, *df* = degrees of freedom.

were still significantly shorter than exclusively heterosexual men.[6]

**2.4 Discussion**

In the current study, it was found, as predicted, that in a nationally representative sample of American adolescents and young adults, exclusively gay men were shorter, on average, than exclusively heterosexual men as adults. In women, there was no statistically significant height difference between exclusively lesbian women and exclusively heterosexual women, which is not what was predicted (although means were in the predicted direction). There were no predicted (i.e., theoretically relevant) variables that emerged as mediator candidates. One unpredicted variable–physical disability of the participant–was a candidate variable for mediation, but was shown to likely not mediate the relationship between sexual orientation and height. Moreover, within men, the sexual orientation and height association was still significant after statistically controlling for stress and nutrition variables that were related to height. Thus, we have found additional support for an objective height difference between gay men and heterosexual men. We did not find evidence that the height difference between gay men and heterosexual men was mediated by stress or nutrition at puberty—a novel result. We found that there was no significant height difference between lesbian and heterosexual women.

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[6] Parental rejection was not included in this analysis, although parental rejection was associated with height, in the unpredicted direction (Table 2.3). We defined a subpopulation of individuals that included male participants with non-missing data on the parental rejection variable. When we conducted the linear regression analysis of sexual orientation predicting height within this subpopulation of participants, the sexual orientation and height association was not significant. This subpopulation of individuals includes a significantly smaller sample size ($n$ = 5655) than for the original analyses within males of the sexual orientation and height association ($n$ = 6475) (with a reduction from $n$ = 126 to $n$ = 105 of gay men). Thus, the association was no longer there in this subsample likely because of a power issue due to loss of sample size needed to detect the small sexual orientation and height effect.

Within both men and women, race/ethnicity and education were significant predictors of objective height, such that White individuals and individuals who have had some university/college education were taller than non-White individuals and individuals who have not had any university/college education. The finding of a significant association between height and race/ethnicity is convergent with other studies that have examined the association between race/ethnicity and height (Komlos, 2010; Komlos & Brabec, 2011; Komlos & Breitfelder, 2008; Skorska & Bogaert, 2016). Also, the finding that greater education is associated with being taller has been found in previous studies (Huang, van Poppel, & Lumey, 2015; Meyer & Selmer, 1999; Palta, Prineas, Berman, & Hannan, 1928).

The finding in the current study that gay men were shorter, on average, than heterosexual men supports other studies that have examined the relationship between sexual orientation and height within men (Blanchard & Bogaert, 1996a; Blanchard et al., 1995; Bogaert, 2010; Bogaert & Blanchard, 1996; Bogaert & Liu, 2013; Skorska & Bogaert, 2016). The height/sexual orientation relationship in the present study is also notable because it is only the second time that an objective height difference was found between gay men and heterosexual men (Skorska & Bogaert, 2016; cf. Blanchard et al., 1995 in which a height difference was found between homosexual and heterosexual men with gender dysphoria). The height/sexual orientation relationship within men is not consistent with the findings of Bogaert and Friesen (2002) or Martin and Nguyen (2004), who did not find a height difference between gay men and heterosexual men. Martin and Nguyen (2004) did, however, find that gay men had shorter long bones of the body (in the arms, legs, and hands) than heterosexual men.

The finding that the height difference between gay men and heterosexual men is likely not mediated by stress or nutrition at puberty lends further support to a more (prenatal) biological interpretation of the association between sexual orientation and height. Thus, we can likely discount an interpretation of the association that involves a pubertal psychosocial stress or nutrition explanation for the association, although this finding needs to be replicated. For recent evidence that biological markers of stress at puberty (i.e., diurnal cortisol) are not elevated in gay adolescents see Austin et al. (2016).

One potential mechanism of the height/sexual orientation relationship in men is the prenatal hormone explanation mentioned in the Introduction. Support for this explanation stems from research demonstrating that height has a biological basis (e.g., Dubois et al., 2012) which has been associated with prenatal hormones. Testosterone stimulates bone growth at the fetal level and throughout an individual’s life either directly or indirectly through aromatization to estrogen or through growth hormone and insulin-like growth factors (Clarke & Khosla, 2009). Moreover, longer fetuses are associated with being taller as adults, although the exact mechanism linking fetal length and adult height is not known (Eide et al., 2005; Sorensen et al., 1999). The prenatal hormone explanation received some indirect support with the findings of Martin and Nguyen (2004), given that long bones of the arms and legs grow before puberty. Also, gay men and heterosexual men did not differ in trunk length and shoulder width, which are sexually dimorphic parts of the body that develop post puberty; again providing indirect support for a mechanism that occurs pre-puberty, although the authors could not address specifically at what time prior to puberty the mechanism occurs. On the other hand, a prenatal androgen interpretation for the sexual orientation and height association in men is complicated by some research showing that men with Klinefelter's syndrome, who have an extra X chromosome (i.e., 47,XXY), are generally tall, but are associated with decreased exposure to prenatal or postnatal androgens (Manning, Kilduff, & Trivers, 2013).

Another potential mechanism involves the fraternal birth order (FBO) effect (i.e., the number of older brothers a man has heightens his chance of being gay), which is hypothesized to be caused by a maternal immune response (e.g., Blanchard & Bogaert, 1996b; Blanchard & VanderLaan, 2015; Bogaert & Skorska, 2011). FBO has been associated with body size (e.g., Blanchard & Ellis, 2001; Bogaert, 2003), including height (Bogaert, 2003). Thus, some mothers may produce an immune response to a male-specific protein that affects both growth and sexual orientation development in later-born boys (e.g., Blanchard, 2004; Blanchard & Klassen, 1997; Blanchard & Bogaert, 1996b; Bogaert & Skorska, 2011).

An additional mechanism may be developmental instability, which can be defined as the degree of genetic or environmental stress that can be experienced by an organism during development (Lalumiere, Blanchard, & Zucker, 2000). A developmental instability explanation has been utilized to explain the finding of increased non-right-handedness in lesbian women and gay men compared to their heterosexual counterparts (Lalumiere et al., 2000). Also, there is some mixed support for the association of increased fluctuating asymmetry (i.e., deviations from perfect symmetry of bodily features) with same-sex sexual orientation (e.g., Lippa, 2003b; Martin, Puts, & Breedlove, 2008; Miller, Hoffman, & Mustanski, 2008; Mustanski, Bailey, & Kaspar, 2002; Schwartz, Kim, Kolundzija, Rieger, & Sanders, 2010), suggesting that developmental instability is linked somewhat to body size. Thus, it is possible that developmental instability may affect both body growth, including height, and sexual orientation in men.

In sum, a number of prenatal factors may account for the height difference between gay and heterosexual men. Future research will be required to determine the exact mechanism, or combination of mechanisms, implicated in this association.

We found that there was no statistically significant height difference between lesbian women and heterosexual women. Although this finding was not what was predicted, it is convergent with other studies that have not found a significant difference in height between lesbian women and heterosexual women (Bogaert, 2010; Bogaert & Friesen, 2002; Bogaert & Liu, 2013; Martin & Nguyen, 2004; Singh et al., 1999; Skorska & Bogaert, 2016). It does not lend support to the height difference found in Bogaert (1998), in which lesbian women were found to be taller, on average, than heterosexual women (see also Martin & Nguyen (2004), who found that lesbian women had significantly longer long bones in the arms and legs than heterosexual women). As was indicated in Skorska and Bogaert (2016), the finding in Bogaert (1998) may be a Type I error, or the lack of other findings in women may be attributed to a lack of power, especially given that the means in, for example, Skorska and Bogaert (2016) were in the expected direction. Here it was also found that means were in the expected direction, although the sample size utilized was comparable to that in Bogaert (1998). Perhaps the effect is so small within women that a larger sample of lesbian women would be required to find it. Future research using larger samples of women might clarify whether studies that have not found the height effect within women are due to a power issue.

Nevertheless, the lack of relationship between sexual orientation and height within women (assuming it is reliable) does not discount the body of research that does suggest a biological basis for the development of sexual orientation in women (e.g., 2D:4D finger length ratios: Brown et al., 2005; Grimbos, Dawood, Burriss, Zucker, & Puts, 2010; McFadden & Shubel, 2002; Rahman, 2005; genetics: Burri, Cherkas, Spector, & Rahman, 2011; Langstrom, Rahman, Carlstrom, & Lichtenstein, 2010; otoacoustic emissions: McFadden & Champlin, 2000; McFadden & Pasanen, 1998, 1999; hormones: Pearcey, Docherty, & Dabbs, 1996; Singh et al., 1999; for reviews see Balthazart, 2011; Bao & Swaab, 2011; Hines, 2011; LeVay, 2010; Ngun et al., 2011). Thus, the finding that one biological correlate is unrelated to sexual orientation in women does not rule out the importance of other biological correlates associated with sexual orientation in women.

There were no significant differences between bisexual individuals and heterosexual individuals, or between bisexual individuals and gay/lesbian individuals in height. Bisexual individuals were more similar in height to gay/lesbian individuals than to heterosexual individuals, based on the pattern of results, which is similar to what was found in Skorska and Bogaert (2016). Perhaps, as in women, the association between bisexuality and height may be very small and thus a larger sample of bisexual individuals may be needed to fully explore the association between bisexuality and height. Future studies could explore this possibility, but could also include different measures of bisexuality that do not assume equal attraction to men and to women within bisexual individuals (e.g., Rieger et al., 2013).

We found support for associations between stressors measured at around the time of puberty and sexual orientation within men. An exclusively gay sexual orientation was associated with greater health stress and presence of suicidal thoughts compared to exclusively heterosexual men. This finding provides additional support for the findings of other studies in which it has been found that same-sex orientation within both men and women is associated with some poorer health outcomes, greater depression, and more suicide than an other-sex orientation (e.g., Boehmer et al., 2012; Collier et al., 2013; Fredriken-Goldsen et al., 2013; Hatzenbuehler et al., 2012; Petterson, VanderLaan, & Vasey, 2016; Ploderl et al., 2013; Rosario et al., 2014; Wichstrom & Hegna, 2003). However, the fact that some stressors were not elevated in gay male adolescents—and even, on some measures, seemed to reflect better adjustment—relative to heterosexual male adolescents also suggests complexity of adjustment, with some sexual minorities having a very good adjustment and a high degree of psychological resilience (e.g., Busseri, Willoughby, Chalmers, & Bogaert, 2006; Rieger & Savin-Williams, 2012; Savin-Williams, 2001).

The finding that a number of measures of stress were associated with being taller within men was unexpected. Perhaps extreme stress would need to occur in order for the negative association to appear, or the negative association only appears in certain subpopulations of male individuals (e.g., those who live in group homes; Johnson & Gunnar, 2011). Moreover, the stress/height relationships were generally modest and only one—physical disability—remained significant in a multivariate context (see Table 2.4). In addition, one methodological detail is of note: participants who could not stand on their own did not have their height measured (Entzel et al., 2009). This methodological detail may have influenced the height and stress association particularly for the physical disability variable, as it seems likely that the people who could not stand might be more severely disabled and likely shorter. Thus, including a full range of people with disabilities may change the height/disability association. Future research will need to be conducted to further explore the relationship between height and stress in men.

**2.4.1 Limitations**

One of the limitations of the current study is that the causal directions of the relationships cannot be completely inferred. The longitudinal design of the data collection affords some causal interpretations (e.g., stressors at Wave I, height at Wave IV), but causal interpretations are still limited because the Add Health data are not longitudinal *and* experimental in design. From an ethical perspective, however, studies incorporating both longitudinal and experimental designs involving sexual orientation research of this nature are unlikely to be conducted. Second, although a number of variables related to stress and nutrition were measured, there may be some variables related to stress and nutrition that were not measured in the Add Health data, and thus not included in the current study, that could play a role in the sexual orientation and height association. Also, some of the stress variables did not achieve high Cronbach's α levels, which could diminish their relationship with sexual orientation and with height. Further, it is possible that stressors at a time earlier than when Wave I data were collected might explain the sexual orientation and height relationship. For example, stressors in childhood may explain the sexual orientation and height relationship (e.g., maltreatment by parents or peers due to any gender nonconformity present in childhood; Petterson et al., 2016; Rieger, Linsenmeier, Gygax, & Bailey, 2008). On the other hand, one might expect stressors in childhood (e.g., due to gender nonconformity) to persist and thus be related to stressors at adolescence, and yet we found little evidence that stressors at adolescence mediate the height/sexual orientation relation in men. Also, although our study suggests a model of the height/sexual orientation relationship where prenatal factors (e.g., prenatal hormones, a maternal immune response) are implicated in this relationship, such factors—or markers of them—were not included in the current study. Thus, further elucidation of the possible role of prenatal factors in this relationship waits new research. Finally, the sexual orientation and nutrition relationship found in the current study should be interpreted with caution given the limited scope with which nutrition was measured in the Add Health data, and given that the analyses were more exploratory.

### 2.4.2 Conclusion

Using a nationally representative sample of American adolescents, additional support was found that gay men are shorter, on average, than heterosexual men. It does not appear that pubertal stress or pubertal nutrition, as assessed by variables computed from the Add Health data, mediate the relationship between sexual orientation and height within men. Thus, other mechanisms (e.g., prenatal hormones, maternal immune response) seem to be better candidates for explaining the height difference between gay men and heterosexual men. Within women, height does not seem to be a reliable physical correlate of sexual orientation and thus cannot be added to the list of biological variables associated with their sexual orientation.

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## Chapter 3: Study 2

Note: This section is based on the following article, with permission: Skorska, M. N., Blanchard, R., VanderLaan, D. P., Zucker, K. J., & Bogaert, A. F. (in press). Gay male only-children: Evidence for low birth weight and high maternal miscarriage rates. *Archives of Sexual Behavior*. doi:10.1007/s10508-016-0829-9
Some parts of this entry differ in the published version of this article. Please contact Malvina Skorska for a list of what has been changed.

### 3.1 Introduction

The study of the biological origins of sexual orientation has been ongoing for several decades now. Researchers investigating sexual orientation have found evidence for the following biological correlates: genetics (e.g., Bailey, Dunne, & Martin, 2000; Bailey & Pillard, 1991; Hamer, Hu, Magnuson, Hu, & Pattatucci, 1993; Mustanski et al., 2005; Sanders et al., 2015), sex-dimorphic brain structures (e.g., Abe, Johansson, Allzen, & Savic, 2014; LeVay, 1991; Witelson et al., 2008), and hormones, particularly at the prenatal level (e.g., Bao & Swaab, 2011; Ellis & Ames, 1987; Grimbos, Dawood, Burriss, Zucker, & Puts, 2010; Hines, 2011; Lalumière, Blanchard, & Zucker, 2000; Ngun, Ghahramani, Sanchez, Bocklandt, & Vilain, 2011). Whereas most of these findings apply to both men and women, a different biological mechanism has been purported to explain the fraternal birth order (FBO) effect that has been found in studies of men's sexual orientation.

In the FBO effect, the odds that men, but not women, will be same-sex attracted as adults are increased with a greater number of older brothers (for reviews, see Blanchard, 1997, 2004, 2008; Blanchard & VanderLaan, 2015; Bogaert & Skorska, 2011; VanderLaan, Blanchard, Wood, & Zucker, 2014). A maternal immune mechanism is a hypothesized biological explanation for this effect. The hypothesis postulates that with each successive male fetus the mother's immune system is repeatedly exposed (and thus potentially immunized) to male-specific proteins associated with the Y-chromosome, which a mother does not have. For a mother who has been immunized, an increasing concentration of antibodies develops after each male fetus and crosses the blood-brain barrier to affect specific areas in the brain associated with the development of sexual orientation, which would then influence the sexual orientation of later born sons (Blanchard & Bogaert, 1996; Blanchard & Klassen, 1997). Recently, Blanchard (2012b) proposed a second maternal-immune based explanation of the etiology of male sexual orientation that is separate from the one related to the fraternal birth order effect.

Blanchard (2012b) found that in a sample of 44,981 heterosexual and gay firstborn men, gay firstborns had significantly fewer younger siblings than heterosexual firstborns. As a possible explanation for this finding of fewer younger siblings in gay firstborn men, Blanchard hypothesized that there might be a maternal immune effect that increases the odds of a gay sexual orientation in a subpopulation of firstborn sons and is associated with a higher likelihood of fetal loss during other pregnancies. Thus, this maternal immune effect would be at least partially distinct from the classic FBO effect. This maternal immune effect should also be more common among the subpopulation of mothers who have had only-child gay males. The logic supporting the selection of this specific subpopulation of sons stems from studies that suggest there are links between a maternal immune response to a fetus, a lower birth weight in a newborn, and secondary recurrent miscarriage. Specifically, a maternal immune response to a fetus can reduce the birth weight of a newborn, and can prevent future pregnancies from reaching full term, rendering the newborn an only child. Blanchard (2012b) hypothesized that in addition to affecting maternal fetal loss and the birth weight of the newborn, the individual's sexual orientation may be affected as well. To support the logic behind this hypothesis, research literature supporting the associations between a maternal immune response and fetal loss, and between a maternal immune response and birth weight, are outlined next, followed by some recent research on only-children, sexual orientation, and birth weight.

A link between fetal loss and a maternal immune effect has been posited in the scientific literature. There is evidence that miscarriages in mothers partially reflect their immune response to a male-specific protein—SMCY—important in male fetal development (Nielson, 2011). SMCY has a relatively generalized role in the development of many structures of the body aside from the brain during sexual differentiation. In sum, elevated fetal loss may serve as a marker of a maternal immune response (e.g., to SMCY or other male-specific proteins).

In addition to fetal loss, a second potential marker of a maternal immune response is birth weight. An association between low birth weight of offspring and a mother's immune system has also been advanced in the scientific literature. For example, research in rodent models has demonstrated that male pups had lower birth weight after maternal immunization to male-specific antigens (Kahn & Baltimore, 2010). In human studies, lower birth weight in both male and female offspring was associated with a mother's immune system activation during pregnancy (Christensen et al., 2012; Kiefte-de Jong et al., 2013; Kusanovic et al., 2007; Milns & Gardner, 1989; Nielsen et al., 2010; Silver et al., 2011) or when the mother and fetus show antigen incompatibility (e.g., incompatible blood groups between the mother and fetus) (Hoff, Peevy, Spinnato, Giattina, & Peterson, 1993). These studies, however, have not investigated the association among birth weight, sexual orientation, and sibship status. There are two published studies examining birth weight in relation to sexual orientation and whether an individual was an only child or an oldest child (i.e., a firstborn with one or more younger siblings).

Blanchard (2012a) demonstrated a significant interaction between sexual orientation and sibship status (i.e., only child versus oldest child), such that the seven lesbian females and six gay males who were only children had a lower birth weight than the 134 heterosexual females and 74 heterosexual males (and there was no significant difference in birth weight between the heterosexual and homosexual oldest children). The mean difference in birth weight was 241.90 g ($d = 0.53$). This pattern was consistent with the hypothesis of a separate etiology for gay only-children, but note that both sexes were represented in these analyses, and thus this study suggests that the separate maternal immune etiology may not be specific to males.

VanderLaan, Blanchard, Wood, Garzon, and Zucker (2015) reported on a sample of 1722 male and female children and adolescents, some of whom were clinically referred for gender dysphoria and others that were clinical controls. Specifically, there were 1536 children (351 girls, 1185 boys) and 173 adolescents (72 girls, 114 males). For the children in their sample, the cross-gender behavior associated with gender dysphoria was treated as an indication that sexual attraction to the same natal sex was a probable adulthood sexual orientation outcome among children (Green, 1987; Singh, 2012; Steensma, McGuire, Kreukels, Beekman, & Cohen-Kettenis, 2013; Wallien & Cohen-Kettenis, 2008). For the adolescents, sexual orientation was classified based on questionnaire responses regarding sexual behavior and attraction. In this sample, the male only-children in the gender dysphoria group ($n = 65$) showed relatively lower birth weight compared with the male only-children in the control group ($n$ = 167) ($p$ = .07, $d$ = 0.27 in males; $p$ = .81, $d$ = -0.06 in females). Thus, a similar pattern emerged as in Blanchard (2012a), but the pattern in VanderLaan et al. (2015) was specific to males.

The goal of the current study was to replicate the birth weight finding in males, given that not all findings for males have been statistically significant. We focused only on natal male births because our data set did not include information about lesbian female births. Also, we conducted the first test of the fetal loss prediction. Specifically, the current study employed a new data set to explore whether male gay only-children have a lower birth weight than male children with other sibship compositions. Also, we examined whether mothers of male gay only-children have experienced greater fetal loss (e.g., miscarriages) than mothers of male children with other sibship compositions. We predicted that (1) mothers of male gay only-children would have more fetal loss than mothers of male children with other sibship compositions and (2) male gay only-children would have a lower birth weight than male children with other sibship compositions.

## 3.2 Method

### 3.2.1 Participants

A total of 159 individuals (12 men, 147 women) participated in a larger study examining the association between a mother's history of immunization to male-specific proteins (as inferred from blood analysis) and her children's sexual orientation. Participants were recruited via posters placed around an Ontario university campus, advertisements placed on Kijiji, booths set up at local Pride festivals, ads placed in local LGBT magazines and radio stations, and ads placed in local newspapers. Ads were targeted for the specific samples required for the larger study. Specifically, ads asked that any interested “mothers of son(s),” “mothers of gay son(s),” “mothers of straight/heterosexual son(s),” “mothers of daughters only,” and “men only” contact the lab for more information about the study via e-mail or phone. Also, six participants were mothers of boys clinically referred to a specialty child and adolescent gender identity service for gender dysphoria.

Of the 159 participants, 12 were men and 147 were women. The women were further classified based on the sex and sexual orientation of their offspring. Thus, 59 were classified as mothers of heterosexual son(s) only (i.e., could have daughters, but sons were heterosexual only), 48 were classified as mothers of at least one gay son (i.e., could have more than one gay son, could have heterosexual sons as well, could have daughters), 11 were classified as mothers of daughters only (i.e., no sons), six were classified as mothers of at least one natal male child clinically referred for gender dysphoria (i.e., could have more than one natal male child who experienced gender dysphoria, could have gay or heterosexual sons, could have daughters), 13 were classified as mothers of sons that had an unknown sexual orientation because their sons were too young to know their sexual orientation (i.e., could have daughters as well), three were classified as mothers of at least one transsexual individual, two were classified as mothers of at least one bisexual son, and five were classified as women who had no known pregnancies.

For the current study, a sub-sample of the recruited participants was of interest. Specifically, we were interested in the main groups from the larger study: mothers of at least one gay son and mothers of heterosexual son(s) only. Thus, the mothers of heterosexual son(s) only ($n$ = 59), mothers of at least one gay son ($n$ = 48), mothers of at least one natal male child clinically referred for gender dysphoria ($n$ = 6), and the mothers of sons that had an unknown sexual orientation ($n$ = 13) were included in the current study, for a total of 126 mothers. The mothers of at least one natal male child clinically referred for gender dysphoria were re-classified as mothers of at least one gay son because most of these gender dysphoric sons were likely to be gay men as adults (Green, 1987; Singh, 2012; Steensma et al., 2013; Wallien & Cohen-Kettenis, 2008). In total, then, 54 mothers had at least one gay son. Similarly, the mothers of sons that had an unknown sexual orientation were re-classified as mothers of heterosexual son(s) only, because 95-98% of these children were likely to be heterosexual as adults (Laumann, Gagnon, Michael, & Michaels, 1994; LeVay, 2010). In total, then, 72 mothers were mothers of heterosexual son(s) only. The majority of the 126 mothers were Caucasian ($n$ = 87; 69%), and were attending or had completed a community college diploma, university degree, or higher ($n$ = 94; 75%). Their ages ranged from 27 to 78 years ($M$ = 51.23, $SD$ = 10.73).

### 3.2.2 Measures

Only the measures of interest to the current study are described below.[7]

*Fetal loss*

Each mother was asked to report the outcome of her pregnancies. Outcomes were labeled by a mother as a miscarriage/abortion, stillbirth, or live birth. For each mother, the number of total miscarriages/abortions and stillbirths was tabulated across all pregnancies to represent the fetal loss variable. Thus, fetal loss represents the total

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[7] Please contact the corresponding author for a list of all measures.

number of fetuses/pregnancies that did not result in a live birth across all known fetuses/pregnancies. See Appendix E for the form each mother was asked to complete for each pregnancy.

*Duration of pregnancy*

Each mother was asked to report the duration of a pregnancy in weeks for pregnancies with all outcomes.

*Birth weight*

Each mother was asked to report the birth weight of each fetus in pounds and ounces, grams, or else indicate that the birth weight was unknown (e.g., if the fetus resulted in a miscarriage). Birth weights reported in pounds and ounces were converted to grams.

*Sex of offspring*

Each mother was asked to report the sex of each fetus using the designation male, female, or unknown.

*Sexual orientation of offspring*

Each mother was asked to report the sexual orientation of each live born child using the labels heterosexual, gay, lesbian, bisexual, transsexual[8], or unknown. Note that mothers of natal male children clinically referred for gender dysphoria did not answer a question about the sexual orientation of their offspring. As indicated above, most natal male children clinically referred for gender dysphoria are likely to be homosexual as adults, with or without continuing gender dysphoria.

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[8] Although "transsexual" does not refer to sexual orientation, we included this designation under sexual orientation in the questionnaire to give mothers another option if one or more of their children had a trans identity.

*Age of mothers at participation*

Each mother was asked to report her date of birth. Age was calculated as the date of examination minus reported date of birth, in years.

**3.2.3 Procedure**

A research assistant and phlebotomist met the participant at their home or on campus (whichever was most convenient). After providing consent, the participant completed a demographics and pregnancy history questionnaire. Along with the measures of reproductive history mentioned above, this questionnaire contained questions related to demographic characteristics of the participant (e.g., age, ethnicity, education). After completion of the questionnaire, a sample of blood was drawn from the participant. Then the participant was thanked, debriefed, and compensated monetarily for their participation. This study was approved by the necessary Research Ethics Boards. See Appendix F for a copy of the ethics clearance certificate.

**3.2.4 Statistical Analyses**

*Fetal loss analyses*

The 126 mothers were first re-classified into five groups based on their pregnancy histories: eight mothers of male gay only-children, 24 mothers of gay males with no older brothers, 22 mothers of gay males with older brothers, 11 mothers of male heterosexual only-children, and 61 mothers of heterosexual males with siblings. Analysis of variance (ANOVA) was used to test whether there were any age differences among the five groups of mothers. Helmert contrasts were used for planned comparisons to determine whether there were any differences among the five groups of mothers (independent variable) in total numbers of fetuses lost (dependent variable). For five groups, Helmert contrasts compare Group 1 with the mean of all later groups (i.e., 2, 3, 4, and 5); Group 2 with the mean of all later groups (i.e., 3, 4, and 5); Group 3 with the mean of all later groups (i.e., 4 and 5); and Group 4 with the mean of all later groups (i.e., 5). The first three groups comprise the mothers of gay males and the latter two groups comprise the mothers of heterosexual males. Group 1 is designated as mothers of male gay only-children because our predictions (based on prior research and theory) concern this group having the greatest number of fetal losses. Group 2 is mothers of gay males with no older brothers because their total reproductive output seems more similar to that of Group 1 mothers compared with Group 3 mothers. Group 3 is mothers of gay males with older brothers because that is the last group of mothers within "mothers of gay males." Group 4 is mothers of male heterosexual only-children because this group seems more similar to Group 1 in terms of total reproductive output than Group 5. Group 5 is mothers of heterosexual males with siblings because that is the remaining group. Omnibus ANOVA was not performed because we had planned comparisons, and with planned comparisons "the researcher moves straight to comparisons" (Tabachnick & Fidell, 2007, p. 52).

A potential confound was that mothers would be expected to have more fetal loss if they are likely to be pregnant more often and thus have more children. Thus, as a second dependent variable, a ratio of the number of lost fetuses to the number of live births was computed.[9] Again, Helmert contrasts were used for planned comparisons with the five groups of mothers as the independent variable and the ratio variable as the

[9] We decided to keep both analyses because the ratio variable is subject to its own limitations (e.g., deviations from non-normality). Thus, we believe a more complete picture can be gleaned from the data by analyzing the fetal loss variable using both non-ratio and ratio variables.

dependent variable. The same group ordering was utilized here as in the previous analysis using Helmert contrasts.

*Birth weight analyses*

In the birth weight analyses, the units of analysis were selected sons rather than the mothers. Because these sons did not actually participate in the study, they are referred to as *subjects* to avoid confusion.

In these birth weight analyses, we addressed a different potential confound: birth weight tends to increase over succeeding pregnancies (Wilcox, Chang, & Johnson, 1996). To control for this possible relation, we restricted the analysis to live-born sons who were the result of their mother's first known pregnancy ($n$ = 64). In other words, we selected subjects who were identical on maternal gravidity (number of pregnancies) and maternal parity (number of deliveries) for their mother's first pregnancy, which is a stricter criterion than controlling for maternal parity alone. Thus, a subset of the sample used to examine fetal loss was used for the birth weight analyses because not all subjects in the fetal loss data were firstborns.

For these birth weight analyses, it is easier to label the sons according to their sibship composition rather than their mothers' reproductive histories, although there is a one-to-one correspondence between the two frames of reference, as discussed below (see also Table 3.1). The sons were categorized as follows: four gay male only-children, eight gay males with no older brothers, 13 heterosexual males with gay younger brothers, 10 heterosexual male only-children, and 29 heterosexual males with siblings (other than gay younger brothers).

It is important to note the correspondence between the groups of mothers studied

Table 3.1. Correspondence between the groups included in the fetal loss analyses and the groups included in the birth weight analyses.

| Fetal Loss Analyses | | | Birth Weight Analyses | |
|---|---|---|---|---|
| Group Name | *n* | Pregnancy History | Group Name | *n* |
| 1. Mothers of male gay only-children | 8 | G | 1. Gay male only-children | 4 |
| 2. Mothers of gay males with no older brothers | 24 | e.g., GHH | 2. Gay males with no older brothers | 8 |
| 3. Mothers of gay males with older brothers | 22 | e.g., HHG | 3. Heterosexual males with gay younger brothers | 13 |
| 4. Mothers of male heterosexual only-children | 11 | H | 4. Heterosexual male only-children | 10 |
| 5. Mothers of heterosexual males with siblings | 61 | e.g., HH | 5. Heterosexual males with siblings | 29 |
| Dependent Variables | | | | |
| Number of fetuses lost by the mother due to miscarriage, abortion, and stillbirth | | | Birth weight of the first-born male only | |

*Note*. G = gay son; H = heterosexual son.

in the analyses of fetal loss and the groups of offspring studied in the analyses of birth weight (see Table 3.1). This correspondence is immediately apparent in four of the five instances (e.g., for the mothers of gay only-children, the offspring were gay only-children). The exception is the mothers of gay males with older brothers, whose first-pregnancy offspring were heterosexual males with gay younger brothers.

ANOVA was used to test whether there were any age differences among the mothers of the five groups of subjects. Helmert contrasts were used in planned comparisons to determine whether there were any differences among the five groups of subjects (independent variable) in birth weight (dependent variable). Groups were ordered the same way as their counterparts in the fetal loss analyses because there was no reason to predict a different group ordering. As with the fetal loss analyses, due to having planned comparisons, omnibus ANOVA was not performed (Tabachnick & Fidell, 2007).

## 3.3 Results

### 3.3.1 Fetal Loss Analyses

The ANOVA with age at examination as the dependent variable was marginally significant, $F(4, 121) = 2.39$, $p = .055$. Planned comparisons were not conducted because there were no a priori expectations of age differences among the groups of mothers used in the fetal loss analyses.

Of the 126 mothers in the sample, 37 reported a loss of 58 fetuses. All but one of these losses was reported as a miscarriage; in the remaining case, the information was missing. Helmert contrasts revealed that the significant difference was found between the mean of the Group 1 mothers compared with the mean of all other groups ($M_{diff} = .87$,

$SE$ = .36, $p$ = .017, *95% CI* = 0.16, 1.58), and between the mean of the Group 3 mothers compared with the mean of all other groups ($M_{diff}$ = .54, $SE$ = .26, $p$ = .041, *95% CI* = 0.02, 1.05) ($M_{Group1}$ = 1.25, $SD_{Group1}$ = 1.39; $M_{Group2}$ = 0.29, $SD_{Group2}$ = 0.69; $M_{Group3}$ = 0.77, $SD_{Group3}$ = 1.74; $M_{Group4}$ = 0.09, $SD_{Group4}$ = 0.30; $M_{Group5}$ = 0.38, $SD_{Group5}$ = 0.64). That is, the mothers of gay only-children had significantly greater numbers of fetal losses compared with the mean of all other mothers ($d$ = 0.80); and the mothers of gay males with older brothers had significantly greater numbers of fetal losses compared with the mean of mothers of heterosexual only-children and the mothers of heterosexual male children with siblings ($d$ = 0.49; see Fig. 3.1).

With ratio of lost fetuses to live births as the dependent variable, Helmert contrasts revealed a significant difference between the mean of the Group 1 mothers compared with the mean of all other groups ($M_{diff}$ = 1.10, $SE$ = .18, $p$ < .001, *95% CI* = 0.75, 1.45) ($M_{Group1}$ = 1.25, $SD_{Group1}$ = 1.39; $M_{Group2}$ = 0.11, $SD_{Group2}$ = 0.25; $M_{Group3}$ = 0.25, $SD_{Group3}$ = 0.57; $M_{Group4}$ = 0.09, $SD_{Group4}$ = 0.30; $M_{Group5}$ = 0.16, $SD_{Group5}$ = 0.28). Thus, the mothers of gay only-children had a significantly greater mean ratio of the number of fetal losses to number of live births compared with the mean of all other mothers ($d$ = 1.56; see Fig. 3.2).

Given the typical non-normal distribution of ratio variables, we also examined these data using non-parametric statistics. The most appropriate analysis is the Kruskal-Wallis test, which is the non-parametric equivalent of an ANOVA (Field, 2013). The mean ranks of the ratio variable differed significantly among the five groups of mothers, $H$ = 11.18, $df$ = 4, $p$ = .025. There are two possible ways to follow-up the Kruskal-Wallis test in SPSS if the omnibus is significant (Field, 2013). We chose the "stepwise step-

**Figure 3.1.** Mean (± SEM) number of lost fetuses for each group of mothers.

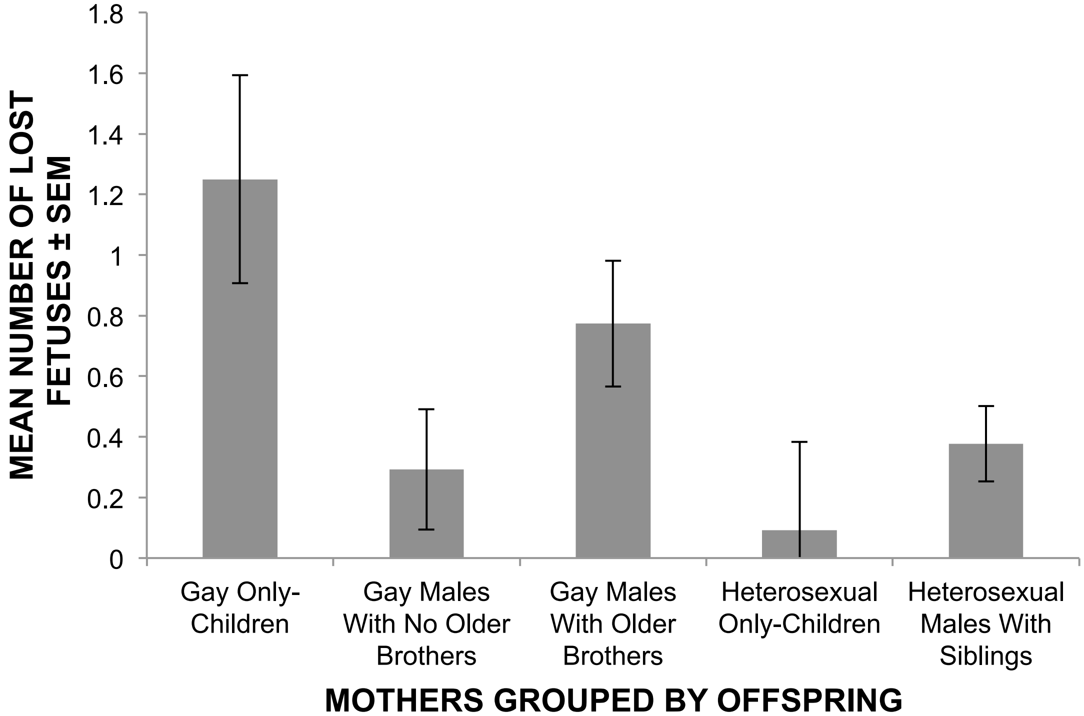
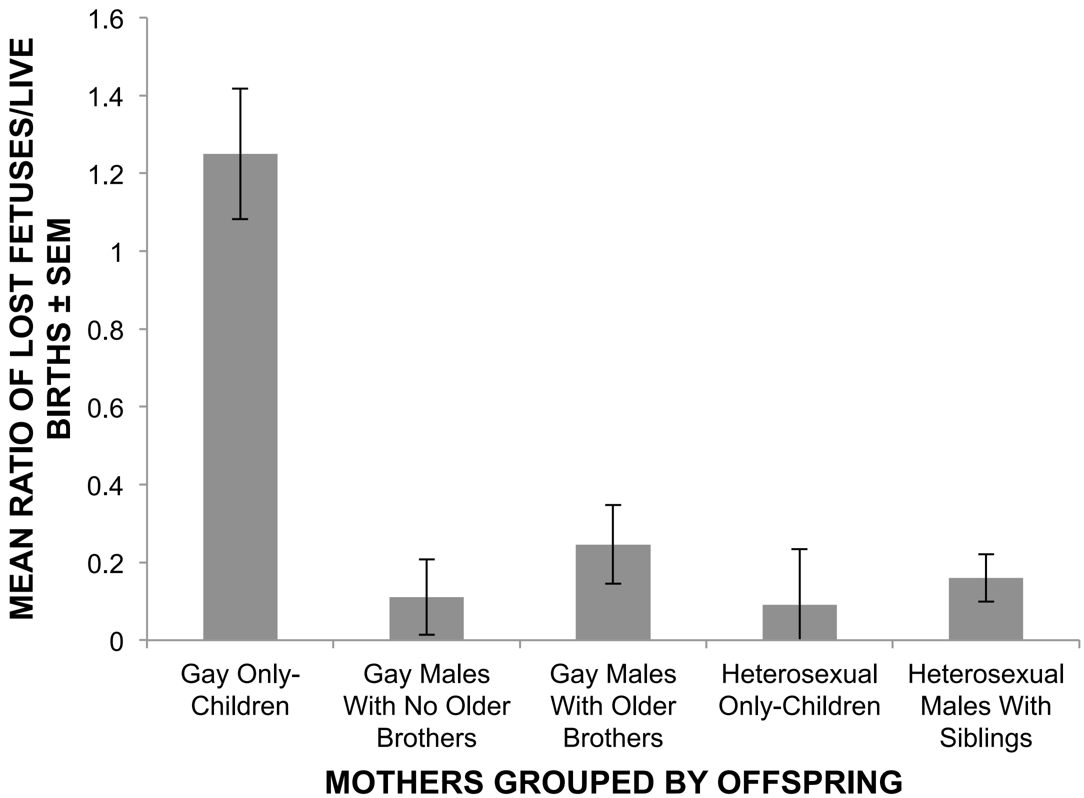


**Figure 3.2.** Mean (± SEM) ratio of lost fetuses to live births for each group of mothers.



down" option, which demonstrated that the mothers of gay only-children were driving the significant omnibus *H*. Specifically, the mothers of gay only-children were a separate group from the four other groups of mothers (mothers of gay males with no older brothers, mothers of gay males with older brothers, mothers of male heterosexual only-children, mothers of heterosexual males with siblings) based on their mean ranks. The four other groups of mothers, however, did not differ significantly from one another in terms of mean ranks ($p = .439$). Thus, the mothers of gay only-children had a significantly greater mean rank of the ratio of the number of fetal losses to number of live births compared with the mean rank of all other mothers, convergent with the results of the parametric test.

**3.3.2 Birth Weight Analyses**

The ANOVA with mother's age at examination as the dependent variable was not significant, $F(4, 59) = 2.06$, $p = .098$. Planned comparisons were not conducted because there were no a priori expectations of age differences among the groups of mothers relevant for the birth weight analyses.

Planned comparisons using Helmert contrasts showed that the predicted birth weight difference between the mean of Group 1 subjects compared with the mean of all other groups of subjects was significant ($M_{diff} = -608.88$, $SE = 257.95$, $p = .022$, *95% CI* = -1125.03, -92.73) ($M_{Group1} = 2967.50$, $SD_{Group1} = 628.72$; $M_{Group2} = 3631.25$, $SD_{Group2} = 542.15$; $M_{Group3} = 3543.85$, $SD_{Group3} = 448.36$; $M_{Group4} = 3508.00$, $SD_{Group4} = 411.60$; $M_{Group5} = 3622.41$, $SD_{Group5} = 510.75$). Thus, the mean birth weight of gay male only-children was significantly lower than the mean birth weight of the first-pregnancy males in all other groups (Fig. 3.3). The difference in birth weight was approximately 600 g, a large effect ($d$ = 1.18).

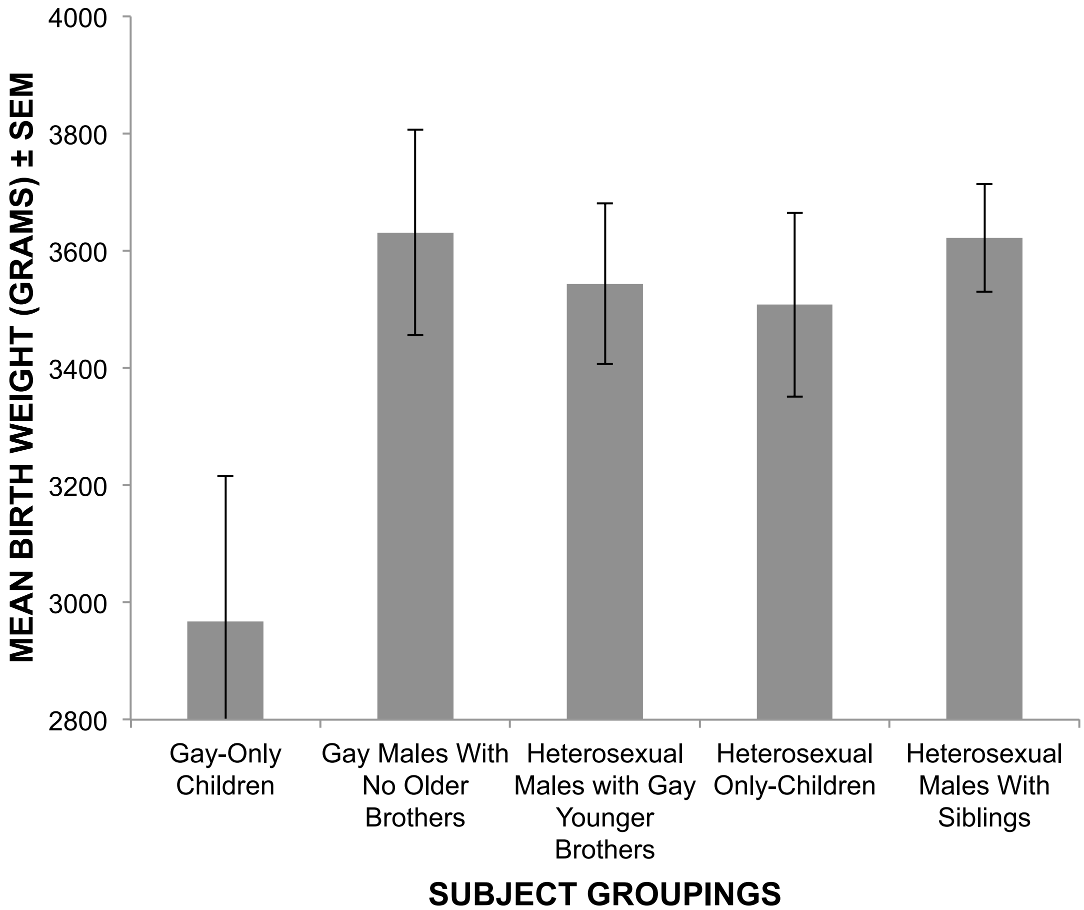
### 3.3.3 Additional Analyses Related to Birth Weight

We conducted a follow up analysis to rule out another explanation for the birth weight effect. Duration of pregnancy did not differ among the same groups of subjects included in the previous analyses, $F(4, 58) < 1$. Thus, mean duration of pregnancy of the first-pregnancy sons was virtually identical for all groups of subjects (and close to the typical 40 weeks).

## 3.4 Discussion

In the current study, we found that mothers of male gay only-children reported, on average, significantly greater mean fetal loss compared with the mean of mothers of gay males with no older brothers, mothers of gay males with older brothers, mothers of male heterosexual only-children, and mothers of heterosexual males with siblings (once total number of pregnancies were controlled for), supporting Prediction 1. Notably, the fetal loss effect was particularly evident for the ratio measurement (fetal loss/live births), an arguably better measure than mean absolute fetal loss, as the former accounts for overall number of pregnancies. Further, we found that the first-gestated gay male only-child had, on average, a significantly lower mean birth weight than the mean of the first-gestated child in each of the following sibship categories: gay males with no older brothers, heterosexual males with gay younger brothers, heterosexual male only-children, and heterosexual males with siblings (other than gay younger brothers), supporting Prediction 2. We have also ruled out a potential explanation of the duration of pregnancy for the

**Figure 3.3.** Mean (± SEM) birth weight for each group of first-pregnancy sons. "Heterosexual Males with Gay Younger Brothers" are first-pregnancy sons of mothers of gay males with older brothers (cf. Figures 3.1 and 3.2). The category-label "Heterosexual Males with Siblings" means siblings that do not include a gay younger brother.



birth weight finding. The former finding regarding fetal loss is novel, whereas the latter finding regarding birth weight is a partial replication and extension of the findings of Blanchard (2012a) within males and VanderLaan et al. (2015).

The present study provided further support for Blanchard's (2012b) hypothesis of a separate etiology of male sexual orientation related to a mother's immune response in gay only-children. Specifically, two markers of a maternal immune response—high fetal loss and low birth weight—were evident in male gay only-children and in the mothers of these children. Indeed, the effects were large (e.g., $d = 1.56$ for fetal loss using the ratio measure, and $d = 1.18$ for birth weight), suggesting that a maternal immune response may be a particularly powerful agent in the etiology of gay male only-child individuals and in the fetal loss of their mothers. In other words, low birth weight and high fetal loss may be markers of a powerful form of a maternal immune response associated with homosexuality in men, but one that is particularly found in gay male only-children compared with male children of other sibship compositions. This type of immune response may be most detectable in gay male only-children because the absence of additional siblings in gay male only-children is a sign that many of their mothers may have been characterized by this powerful immune response resulting in elevated fetal loss (and hence no other children).

Regarding lower birth weight among gay male only-children, the effect size found in the current study ($d = 1.18$) was larger compared with the effect size of $d = 0.53$ found in Blanchard (2012a) and $d = 0.27$ found in VanderLaan et al. (2015). These differences in effect size across studies may be due to the diversity of the samples, the different and various sexual orientation measures utilized in the studies, or the various sibship composition breakdowns in the studies. Further research with larger sample sizes and detailed sibship compositions will help to clarify the effect size related to the birth weight of gay only-children.

We can only speculate about the specific maternal immune mechanisms that underlie this potential second type of maternal immune response. VanderLaan et al. (2015) postulated that mothers who carry the HLA class II allele, *HYrHLA*, and a homozygous 14 base pair in exon 8 of the *HLA-G* gene would be more likely to have a gay son. This hypothesis was proposed because of previous literature indicating *HYrHLA* increased a mother's immune response to male-specific minor HY antigens; *HYrHLA* was associated with low birth weight in firstborn sons (not firstborn daughters); and the homozygous base pair insertion in exon 8 of the *HLA-G* gene was associated with greater miscarriages after the birth of the first child (Christensen et al., 2012). The investigation of whether this specific genotype in mothers can explain the putative second type of maternal immune response found in the current study, in Blanchard (2012a), and in VanderLaan et al. (2015), will have to await future research.

There may also be different male-specific proteins associated with the classic FBO maternal immune effect and this second potential maternal immune effect associated with gay only-children. As mentioned in the Introduction, SMCY is reported to underlie fetal miscarriages (Nielson, 2011) and thus this male-specific protein may play a role in the effects associated with this second potential maternal immune response in gay only-children. During sexual differentiation, SMCY has a relatively generalized role in the development of many structures of the body aside from the brain and thus maternal anti-SMCY (e.g., antibodies to SMCY) likely has dramatic effects on the fetus (i.e., miscarriage). If so, mothers of gay only-children may be characterized by a powerful immune response that includes reactions to a number of male-specific proteins (including SMCY), which have particularly powerful effects on additional male fetuses. In contrast, mothers of gay men with older brothers may have had a weaker but a more specialized immune response to one or more male-specific proteins associated with brain development more directly (e.g., PCDH11Y or NLGN4Y; for reviews, see Blanchard, 2008; Bogaert & Skorska, 2011). Again, this speculation waits further testing.

### 3.4.1 Limitations and Future Directions

This study cannot address the association between sibship composition, sexual orientation, and birth weight in women; as such, Blanchard's (2012a) finding that lesbian only-children had lower birth weights than female heterosexual only-children—and VanderLaan et al.'s (2015) lack of such a finding—will require further investigation. If the second type of maternal immune effect is indeed replicated in women, the explanations posited in the current study may not apply. For example, it may be the case that a maternal immune response to a non-male-specific protein may be occurring (Blanchard, 2012a); however, future research is required to fully elucidate whether the effect occurs in women and, if so, why. Also, studies utilizing a larger sample size will be required to replicate and extend the current study. Blanchard's (2012a) suggestion of an online survey seems to be a straightforward methodological suggestion to manage the sample size problem. Further, the current study relied on self-reports of fetal loss and birth weight. Although parent-reports of birth weight seem to be very accurate (e.g., VanderLaan et al. reported $r = .97$, $p < .001$ for a subset of participants for whom both hospital records and parent-report birth weight was available), the accuracy of self-reports of fetal loss may be much lower. For example, some women may experience a miscarriage without knowing that one occurred. Hospital records and a longitudinal study following mothers throughout their childbearing years may help with determining whether self-reports are reliable indicators of fetal loss; however, both options are less practical than the self-reporting of fetal loss by mothers. Nevertheless, future research incorporating other ways to measure fetal loss would be beneficial.

### 3.4.2 Conclusion

We found that mothers of male gay only-children experienced greater mean fetal loss compared with mothers of males with other sibship compositions. Also, we found that first-gestated gay male only-children had a lower mean birth weight than first-gestated male children with other sibship compositions. In sum, the current study provides additional support for the hypothesis that a separate etiology of male sexual orientation related to a mother's immune response exists—one that is particularly powerful and most detectable in gay male only-children.

## 3.5 References

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## Chapter 4: Study 3

Note: This section is based on the following article, with permission: Skorska, M. N., Geniole, S. N., Vrysen, B. M., McCormick, C. M., & Bogaert, A. F. (2015). Facial structure predicts sexual orientation in both men and women. *Archives of Sexual Behavior*, *44*, 1377-1394. doi:10.1007/s10508-014-0454-4
Some parts of this entry differ in the published version of this article. Please contact Malvina Skorska for a list of what has been changed.

### 4.1 Introduction

The most commonly cited biological models of the origins of sexual orientation implicate variations in fetal androgen signaling on sexual differentiation (Bao & Swaab, 2011; Breedlove, 2010; Rice, Friberg, & Gavrilets, 2012). Nevertheless, there is only modest evidence of physical differences between gay/lesbian and heterosexual individuals suggestive of atypical sexual differentiation (e.g., Schwartz, Kim, Kolundzija, Rieger, & Sanders, 2010). The physical differences that have been found are not found consistently and have weak effect sizes, thus accounting for little of the variance in sexual orientation (Hines, 2011; LeVay, 2010). For example, in a meta-analysis investigating the relationship between sexual orientation and the ratio of the second to fourth digit (2D:4D ratio; tends to be larger in women than in men and is a putative marker of variation in prenatal androgen signaling), there was a small effect of sexual orientation on 2D:4D ratios for women (heterosexual women > lesbian women; Hedges' $g = 0.29$ for the right hand and 0.23 for the left hand), but no effect for men (Grimbos, Dawood, Burriss, Zucker, & Puts, 2010; see also Williams et al., 2000). Further, despite a marked sex difference in height, which is influenced by both prenatal and postnatal factors including androgens, the difference in height between gay and heterosexual men is small (e.g., $d = 0.21$ in Bogaert, 2010). There is also little or no difference in height between lesbian and heterosexual women (e.g., Bogaert, 2010; Bogaert & Liu, 2013).

In addition, when other physical characteristics have been associated with sexual orientation, this association has not always been interpreted in light of fetal androgens. For example, although handedness was originally conceptualized as being associated with sexual orientation due to sexual differentiation processes, the relationship between handedness and sexual orientation has more recently been argued to be influenced by a number of factors other than fetal androgens (Lalumiere, Blanchard, & Zucker, 2000). Based on a sex difference in handedness, such that men are more likely to be non-right-handed than women, a meta-analysis indicated that gay men were 34% more likely than heterosexual men to be non-right-handed, and lesbian women were 91% more likely than heterosexual women to be non-right handed (Lalumiere et al., 2000). This corresponds to $d = 0.16$ in men and $d = 0.36$ in women, conventionally small and moderate effect sizes (Tabachnick & Fidell, 2007). Overall, gay/lesbian individuals were 39% more likely than heterosexual individuals to be non-right handed (Lalumiere et al., 2000), which corresponds to $d = 0.18$, a small effect size. Although other explanations exist, developmental instability, or deviations from perfect development influenced by environmental or genetic factors, was forwarded as the most plausible explanation for the findings of the relationship between sexual orientation and handedness. Left-handedness has been associated with markers of developmental instability. The increased likelihood of non-right-handedness in gay and lesbian compared to heterosexual individuals suggests that gay/lesbian individuals were under increased instability in early development compared to heterosexual individuals (Lalumiere et al., 2000). In sum, other mechanisms beyond androgen signaling have been proposed to explain variation in sexual orientation related to physical characteristics (e.g., developmental instability, genetic variation, maternal immune response), and these mechanisms may not always be mutually exclusive or independent of one another (Blanchard, 2008; Bogaert, 2007; Williams et al., 2000).

One physical characteristic, facial structure, has not been extensively studied in relation to sexual orientation. Facial structure is also affected by factors beyond sexual differentiation mechanisms, including developmental instability and genetic variation (Greene & Pisano, 2010; Jelenkovic, Poveda, Susanne, & Rebato, 2010). Sexual differentiation, however, is a common mechanism used to explain the development of facial structure because men and women differ in facial structure. Male faces generally have longer jaws, wider jaws, smaller eyes, larger noses, and more prominent brow ridges, whereas female faces generally have larger eyes, smaller brow ridges, smaller jaws, smaller chins, and fuller lips (Burke & Sulikowski, 2010; Rhodes, 2006). The development of the sexual dimorphism of faces is guided by both prenatal and postnatal factors (Bulygina, Mitteroecker, & Aiello, 2006; Enlow, 1982; Meindl, Windhager, Wallner, & Schaefer, 2012; Verdonck, Gaethofs, Carels, & de Zegher, 1999).

Hughes and Bremme (2011), who conducted one of two known studies of the relationship between sexual orientation and facial structure, reported reduced masculinity in gay relative to heterosexual men, but they were unable to identify the specific facial features underlying the reduced masculinity. Further, they did not find any significant differences between lesbian and heterosexual women. Specifically, gay and heterosexual men, as well as lesbian and heterosexual women, did not differ on seven separate proportional measures of sexually dimorphic facial characteristics (eye size, lower face/face height, cheekbone prominence, face width/lower face height, mean eyebrow height, forehead height, and lip/jaw width). After calculating a composite measure using these seven facial characteristics in an attempt to tap into overall facial masculinity/femininity, gay men had reduced facial masculinity relative to heterosexual men, but the composite masculinity/femininity measure was not associated with sexual orientation in women (Hughes & Bremme, 2011). Their study was limited, however, due to a small sample of photographs (*n* = 15 per group) that were obtained from websites and in the number of facial features examined.

In another study in Czech men that involved geometric morphometric analyses, significant differences were found between the shape of the faces of gay men compared to the shape of the faces of heterosexual men (Valentova, Kleisner, Havlicek, & Neustupa, 2014). In a qualitative follow-up analysis, it was found that gay men had shorter noses, a longer distance between the nose and mouth (i.e., longer philtrum), and a shorter distance between eyes and mouth compared to heterosexual men. Also, gay men had corners of the mouth oriented downwards, the shape of the oral cleft was convex, and gay men had a rounded and wider chin compared to heterosexual men. These characteristics suggest that gay men have a wider, shorter, and more globular facial form compared to the longer and narrower facial form of heterosexual men. In addition, these characteristics seem to reflect a mixture of both masculine (e.g., wider faces; rounded jaws) and feminine (e.g., shorter noses, shorter faces) facial features in gay men. This study was limited, however, by examining a small sample of men only, and by conducting only qualitative analyses to delineate the specific facial features that differ between gay and heterosexual men.

Examination of the facial features that differ between gay/lesbian and heterosexual individuals is partially fuelled by several studies providing empirical support for sex-based heuristics or stereotypes that guide judgement of sexual orientation based on the face (e.g., men's faces perceived to be more feminine in terms of face shape and texture were more likely to be judged as gay) (Freeman, Johnson, Ambady, & Rule, 2010; Stern, West, Jost, & Rule, 2013; Valentova et al., 2014). In addition, there is evidence of accuracy in judgements of sexual orientation based on facial photographs (which has been termed "gaydar") (Rule & Ambady, 2008; Rule, Ambady, Adams, & Macrae, 2007; Rule, Ambady, Adams, & Macrae, 2008; Rule, Ambady, & Hallett, 2009). A meta-analysis found that the overall effect size for accurately categorizing targets based on sexual orientation was $r = .29$, with about 64.5% of targets that would be correctly categorized. Further, accuracy in judgments of sexual orientation has been associated with sex-based heuristics (Freeman et al., 2010). Valentova et al. (2014), however, found that while ratings of homosexuality were associated with ratings of femininity, the gay men in their sample were rated as more masculine, so ratings of sexual orientation did not predict the actual sexual orientation of targets.

In several of these gaydar studies, the photographs of faces were obtained from dating websites, similar to Hughes and Bremme (2011; cf. Valentova et al., 2014). Examining facial features from photographs obtained from websites may reveal more about presentation of the self or the types of partners being sought than about the facial morphology that is associated with sexual orientation, although Rule and Ambady (2008) and Rule et al. (2008) attempted to address the self-presentation issue. An additional concern present in the gaydar studies is that hairstyle is not cropped out of the photographs of targets for rating of sexual orientation (e.g., Rule & Ambady, 2008; Rule et al., 2007, 2009). Given that hairstyle does play a role in judgements of sexual orientation (Rule et al., 2008), it is difficult to tease apart effects of hairstyle from effects due to perception of *only* facial cues in the studies that limited their photographs to ones solely with hairstyle. Nevertheless, faces with hairstyle occluded were still judged with some accuracy for sexual orientation, albeit less than just hairstyle alone, and less than a face with hairstyle together (Rule et al., 2009). Thus, sampling and standardization of photographs must be taken into account to determine whether there are actual differences in the facial characteristics of gay/lesbian and heterosexual individuals.

In summary, there may be sexually dimorphic facial features that differ between heterosexual and gay/lesbian individuals in the direction supported by androgen signalling theory (e.g., gay men have more feminine facial features) that cue judgements of sexual orientation, such as face shape, width of jaw, and length of face (Freeman et al., 2010; Tskhay & Rule, 2013; Valentova et al., 2014). Further, there may be sexually dimorphic facial features that differ between heterosexual and gay/lesbian individuals that cannot be explained by androgen signalling theory (e.g., gay men have more masculine facial features) but that cue judgements of sexual orientation, such as width of face and length of nose (for evidence of this in men, see Valentova et al., 2014). Also, it is theoretically possible that there may be facial features that differ between heterosexual and gay/lesbian individuals that are independent of sex, although this has not been demonstrated in previous research.

We tested these possibilities—i.e., sexual orientation is related to facial structure via sexual differentiation mechanisms (e.g., androgen signalling) or via non-sexual differentiation mechanisms (although we did not test the mechanisms directly)—through the use of a facial modelling program that provided 63 facial metrics from photographs of a sample of both men and women. The subjects also completed extensive demographic information, including completion of several measures for classification of sexual orientation. The current study extended the work previously done on the relationship between sexual orientation and facial structure by: (1) Utilizing a sample of men somewhat larger than that examined by Valentova et al. (2014) and by Hughes and Bremme (2011); (2) Including a sample of women (women were not included in Valentova et al. and our sample was somewhat larger than the sample of women examined by Hughes and Bremme); (3) Utilizing more standardized photographs, similar to Valentova et al., but unlike the photographs examined by Hughes and Bremme which were collected from online websites; (4) Utilizing a quantitative approach to deducing the facial features related to sexual orientation, which expands on the quantitative approach used by Hughes and Bremme and extends the qualitative approach used by Valentova et al.; and (5) Capitalizing on the quantitative approach offered by our methodology to utilize different data reduction techniques to deduce the facial features related to sexual orientation.

## 4.2 Method

### 4.2.1 Subjects

Photographs were selected from a database including 906 subjects. Only those fitting the definition of gay/lesbian and heterosexual based on questionnaire responses were included. Subjects indicated their sexual attraction on a 1 to 7 Likert scale (exclusively homosexual/gay/lesbian to exclusively heterosexual/straight). Specifically, subjects rated themselves on the following question: "In terms of my sexual thoughts and feelings, I am" on the Likert scale. Subjects also indicated their identity by checking whether they were homosexual/gay, homosexual/lesbian, bisexual, heterosexual/straight, asexual ("lack of attraction to either sex"), or other, with a space to specify what they referred to as other. Subjects were selected if their Likert score was $\leq 2$ (i.e., exclusively or near exclusively homosexual) and they self-identified as "homosexual/gay/lesbian" or if their Likert score was $\geq 6$ (i.e., exclusively or near exclusively heterosexual) and they self-identified as "heterosexual/straight." Only White subjects were included to remove variation in facial structure attributable to ethnicity (Fang, Clapham, & Chung, 2011). Some were excluded because they were not posed in neutral expressions, were not facing the camera directly, or the face was obscured. An additional three women were removed from final analyses when identified as multivariate statistical outliers (Cohen, Cohen, West, & Aiken, 2003). Thus, the final sample consisted of 390 facial photographs (52 lesbian women, 134 heterosexual women, 77 gay men, 127 heterosexual men).

### 4.2.2 Procedure

The photographs were taken with a Nikon D3100 digital SLR camera in RAW format by the first author. Each photograph was converted to TIFF format prior to inputting into the FaceGen program (a facial modelling program) (Singular Inversions, 2010). Once inputted into the FaceGen program and after receiving training, the third author, who was blind to the sexual orientation of the subjects in the photographs, fitted each face to the points on the face required by FaceGen to compute the necessary numerical values. Subjects were instructed to pose with a neutral facial expression, to remove glasses, and to wear a hair net or hold back any hair that was obstructing their face if a hair net was unavailable. Subjects were recruited at Brock University or at various Pride or sexuality events across Canada (e.g., Toronto Pride, Montreal Pride, Vancouver Pride, Everything to do with Sex Show Toronto) to participate in a larger study on Sexuality and Physical Development. Note that not all subjects recruited on campus were heterosexual and not all subjects recruited at Prides were gay/lesbian. For photographs taken at Brock University, the camera was placed on a tripod, approximately 2 metres away from each subject, as they stood straight against a wall. The height of the camera was adjusted so that the lens of the camera was at the same height of the subject's face. For photographs shot off campus, the camera was held in hand when shooting and an attempt was made to stand 2 metres away from each subject, although this distance was not always possible due to the conditions at the various events. A hairline to chin distance of 400 pixels was used to standardize the photographs to control for any variation in distance from the camera to the face. Subjects were paid or given course credit for participation, and provided consent to participating in the study and to having their photograph taken for structural analyses only. See Table 4.1 for descriptive statistics related to this sample. The original data collection and the current study were approved

Table 4.1. Descriptive statistics for the sample.

| Predictors | Gay Men (n = 77) *M* (*SD*) | Heterosexual Men (n = 127) *M* (*SD*) | Heterosexual Women (n = 134) *M* (*SD*) | Lesbian Women *M* (*SD*) (n = 52) |
|---|---|---|---|---|
| Age (years) | 31.08 (12.55) | 22.87 (8.28) | 20.66 (4.81) | 27.69 (10.95) |
| Height (cm) | 177.28 (8.16) | 177.60 (7.15) | 164.32 (6.75) | 164.93 (6.51) |
| Weight (kg) | 79.39 (16.20) | 77.87 (12.77) | 64.96 (11.71) | 72.09 (16.54) |
| BMI | 25.19 (4.37) | 24.69 (3.81) | 24.03 (4.03) | 26.53 (6.03) |

by the Brock University Research Ethics Board. See Appendix G for a copy of the ethics clearance certificate.

**4.2.3 Measures**

FaceGen utilizes statistical algorithms derived from 3D laser scans of a sample of human faces. From these algorithms, 62 facial metrics are provided in standardized units, which range on a continuum from high to low. Sixty-one of these facial metrics have numerical values and can be grouped into 10 featural categories (e.g., cheeks, nose). An additional shape metric, not associated with a numerical value, consisted of an analogue sliding scale along a masculine-feminine dimension (see also Carpinella & Johnson, 2013; Yang, Shen, Chen, & Fang, 2011). We placed a ruler on the scale to obtain a numerical value that corresponded with the degree to which a face was masculine or feminine. That is, the ruler was placed on the computer screen to measure the distance that the slider was at on the scale, which was anchored by 100% male on one end and 100% female on the other end (inter-rater reliability: $r = .99$, $p < .01$). It is important to note that the shape metric is not an average measure of other facial metrics that FaceGen provides that are related to sex. While sex is correlated with several of the facial metrics, the shape metric is a separate metric provided by FaceGen that globally assesses differences in the shape of the face between men and women. Also, the shape of the face has been found to discriminate strongly between male and female faces (Yamaguchi, Hirukawa, & Kanazawa, 1995). The 63$^{rd}$ metric, facial width-to-height ratio (bizygomatic width divided by upper face height) was also measured (Carré & McCormick, 2008).

Table 4.2. Partial correlations between the facial metrics, sex, and sexual orientation.

| Facial Metrics | Sex | Sexual Orientation Men (*n* = 204) | Sexual Orientation Women (*n* = 186) |
|---|---|---|---|
| Shape: feminine | **-.42** | .03 | **-.23**[c] |
| Facial Width-to-Height Ratio | .05 | .00 | -.07 |
| *Brow Category* | | | |
| Brow Ridge: low | .09 | .05 | -.03 |
| Brow Ridge Inner: up | .01 | -.09 | .05 |
| Brow Ridge Outer: down | .11 | .05 | -.06 |
| *Cheek Category* | | | |
| Cheekbones: high | **.12** | **-.21**[a] | .00 |
| Cheekbones: pronounced | -.10 | .02 | -.10 |
| Cheekbones: wide | -.02 | .00 | -.07 |
| Cheeks: convex | .10 | **.22** | **.27** |
| Cheeks: gaunt | **.16** | .05 | .12 |
| *Chin Category* | | | |
| Chin: backward | .03 | -.03 | .08 |
| Chin: recessed | .05 | -.02 | -.07 |
| Chin: jutting | -.02 | .01 | .05 |
| Chin: deep | **-.18** | -.01 | **-.19**[c] |
| Chin: large | .08 | -.09 | .12 |
| Chin: short | .09 | .02 | -.03 |
| Chin: thin | .08 | .02 | -.06 |
| *Eyes Category* | | | |
| Eyes: up | **.20** | .10 | **.19**[c] |
| Eyes: large | **-.27** | .03 | -.12 |
| Eyes: tilt outward | .08 | **.15** | .00 |
| Eyes: together | -.02 | -.09 | .04 |
| *Face Category* | | | |
| Face: brow-nose-chin ratio | **.23** | .06 | **.23**[c] |
| Face: forehead-sellion-nose ratio | -.07 | .04 | -.06 |
| Face: light | .03 | .04 | -.05 |
| Face: gaunt | **-.15** | .13 | .14 |
| Face: short | **-.13** | -.04 | -.13 |
| Face: down | .04 | -.07 | -.07 |
| Face: thin | -.07 | -.08 | -.10 |
| *Forehead Category* | | | |
| Forehead: large | **-.12** | -.13 | **-.36**[c] |
| Forehead: short | .04 | .10 | .13 |
| Forehead: tilt back | .03 | **.16** | **.19** |
| *Head Category* | | | |
| Head: thin | -.10 | .06 | .09 |
| Temples: wide | -.01 | -.08 | -.10 |
| *Jaw Category* | | | |
| Jaw: jutting | -.02 | .01 | .06 |

| | | | |
|---|---|---|---|
| Jaw: thin | **-.16** | .00 | -.08 |
| Jaw-Neck-Slope: low | .00 | .02 | .08 |
| Jawline: convex | .01 | .04 | .09 |
| *Mouth Category* | | | |
| Mouth: pursed | .11 | .02 | -.10 |
| Mouth: sad | **.18** | -.06 | .07 |
| Mouth: Lips inflated | .07 | .13 | **.28** |
| Mouth: Lips small | **-.18** | **-.16**[b] | **-.31**[c] |
| Mouth: Lips retracted | .03 | **-.18** | **-.30** |
| Mouth: Lips thick | **.18** | .13 | .01 |
| Mouth: retracted | -.07 | **-.24** | **-.42** |
| Mouth: tilt down | **-.24** | -.11 | **-.33**[c] |
| Mouth: overbite | **-.32** | -.05 | **-.28**[c] |
| Mouth: down | **.27** | .00 | .08 |
| Mouth: thin | **-.15** | -.03 | **-.20**[c] |
| Mouth-Chin Distance: long | **-.25** | -.03 | -.04 |
| *Nose Category* | | | |
| Nose: bridge deep | **.24** | **-.28**[a] | -.09 |
| Nose - bridge long | **-.19** | .03 | -.12 |
| Nose: up | **.21** | .01 | **.15**[c] |
| Nose: pointed | **.21** | **-.24**[a] | **-.15**[d] |
| Nose: nostril tilt up | .11 | -.05 | .06 |
| Nose: nostrils large | **.25** | **-.17**[a] | -.14 |
| Nose: nostrils thin | **-.20** | -.08 | -.11 |
| Nose: region convex | -.11 | .08 | .06 |
| Nose: sellion up | **-.12** | -.07 | -.04 |
| Nose: sellion deep | .10 | -.01 | .07 |
| Nose: sellion deep | **.23** | .13 | .13 |
| Nose: sellion wide | **.14** | -.02 | -.01 |
| Nose: long | **.21** | **-.30**[a] | **-.23**[d] |
| Nose: tilt up | .05 | -.04 | -.03 |

*Note*. The numbers represent partial correlations between the facial metrics and sex (0 = heterosexual women, 1 = heterosexual men; positive correlations indicate heterosexual men have more of the metric than heterosexual women, whereas negative correlations indicate they have less), and between the facial metrics and sexual orientation (0 = heterosexual, 1 = gay/lesbian; positive correlations indicate gay/lesbian individuals have more of the metric than heterosexual individuals, whereas negative correlations indicate they have less), statistically controlling for age, height, and weight. Correlations in bold are significant ($p \leq .05$).

[a] Metric is more feminine in gay than in heterosexual men.
[b] Metric is more masculine in gay than in heterosexual men.
[c] Metric is more masculine in lesbian than in heterosexual women.
[d] Metric is more feminine in lesbian than in heterosexual women.

### 4.2.4 Data Analysis

*Overview of Facial Metrics in the Main Analyses*

First, among heterosexual subjects (127 men, 134 women), we examined partial correlations (controlling for age, weight, and height) between each facial metric and sex (see Table 4.2) to determine which of the facial metrics, used in the final model to predict sexual orientation, differed for the sexes. Further, facial metrics that shared significant (*p*s $\leq .05$) partial correlations (controlling for age, height, and weight) with sexual orientation within each sex were selected for the main analyses (see Table 4.2). When two or more metrics (e.g., cheekbones high and cheeks convex) within the same featural category (e.g., cheeks) were associated with sexual orientation, they were included in the first model only if they uniquely predicted sexual orientation in a logistic regression with age, height, and weight on Step 1 and the relevant facial metrics on Step 2. This approach is somewhat conservative, but given the high number of predictors, this approach minimized the likelihood of making Type I errors and reduced multicollinearity issues in the main analyses. Standardized residuals were created within each sex, controlling for age, weight, and height, for each of the facial metrics to be included in the main analyses. Thus, in the main analyses, within each sex, the residuals of unique metrics *within a featural category* (based on partial correlations and/or logistic regressions, as outlined above) were entered as simultaneous predictors in a binary logistic regression to determine which shared unique associations with sexual orientation. Of these, only the residuals of unique metrics predicting sexual orientation (i.e., $p \leq .10$) were included in the final model.

*Overview of Analyses Using Alternative Data Reduction Techniques*

Although the logistic regression allowed us to pinpoint specific unique facial metrics that differed between individuals that were gay/lesbian or heterosexual, it did not allow for the identification of linear combinations of features that may better discriminate between gay/lesbian and heterosexual individuals. For example, although a retracted mouth may differentiate lesbian and heterosexual women, a mouth that involves a combination of having thin lips and being retracted may be an even better correlate of sexual orientation. Thus, we utilized two different analyses–principal components analysis (PCA) and discriminant function analysis (DFA)–to examine linear combinations of facial metrics.

In the PCA, the total set of facial metrics was reduced into a smaller number of components. The components represented linear combinations of facial metrics that were arranged and combined such that they accounted for the most amount of variability possible in the total set of facial metrics. For ease of component interpretation, this analysis was conducted using varimax rotation, which reduces variable loadings that are weak and strengthens variable loadings that are strong, therefore minimizing the cross-loading of facial metrics on multiple components (Tabachnick & Fidell, 2007). First, standardized residuals were created for each of the facial metrics in the entire sample, controlling for age, weight, and height. Then, the PCA reduced the total set of facial metrics into a smaller number of components and the component scores were saved for each subject. The component scores were then used as independent variables in two logistic regressions conducted within each sex, to predict sexual orientation. To determine which components differed for men and for women (i.e., were sexually dimorphic), we conducted point-biserial correlations within heterosexual subjects ($n$ = 261) between the component scores for each component and sex.

In the DFA, group membership (heterosexual women, lesbian women, heterosexual men, gay men) was predicted by linear combinations of variables called discriminant functions. Specifically, the discriminant functions are created to allow for the best separation between the groups. If the groups differ on more than one linear combination of variables, an additional discriminant function will form. The maximum number of discriminant functions that can be formed is equal to the lesser of the number of predictors minus one or the number of groups minus one (Tabachnick & Fidell, 2007). Therefore, in the current analysis, which involved four groups, a maximum of three discriminant functions were able to form. First, standardized residuals were created for each of the facial metrics in the entire sample to control for age, weight, and height. Then, the 63 facial metrics were entered as independent variables in a DFA with group membership (0 = heterosexual women, 1 = lesbian women, 2 = heterosexual men, 3 = gay men) as the dependent variable.

DFA is more robust against the violation of certain assumptions if there are as many subjects in the smallest group as there are predictors in the model. Although we had 63 predictors, 9 of these predictors (nose bridge: short long, nose: down up, nose region: concave convex, nose sellion: down up, nose sellion: shallow deep, nose sellion: thin wide, nose: short long, nose tilt: down up, temples: thin wide) were removed from the analysis because they failed to pass the tolerance test (i.e., they shared substantial overlap with other predictors). Thus, 54 of the 63 facial metrics were included as independent variables in the final DFA with group membership (0 = heterosexual women, 1 = lesbian women, 2 = heterosexual men, 3 = gay men) as the dependent variable.

## 4.3 Results

### 4.3.1 Group Differences

There were group differences in age (ANOVA, $n = 390$: $F(1, 386) = 8.53$, $p = .004$, men > women; $F(1, 386) = 63.32$, $p < .001$, gay/lesbian individuals > heterosexual individuals; $p$s < .01), weight (ANOVA, $n = 390$: $F(1, 386) = 45.63$, $p < .001$, men > women; $F(1, 386) = 8.36$, $p = .004$, gay/lesbian individuals > heterosexual individuals, $p$s < .01), and height (ANOVA, $n = 390$: $F(1, 386) = 270.09$, $p < .001$, men > women, $p < .001$; see Table 4.1 for descriptive statistics). There were also associations of facial structure with age ($-.34 \leq r \leq .33$, $p$s $\geq .001$), weight ($-.35 \leq r \leq .41$, $p$s $\geq .001$), and height ($-.33 \leq r \leq .32$, $p$s $\geq .001$)[10]. Thus, age, weight, and height were controlled statistically in all analyses (details provided when each analysis is described below)[11].

### 4.3.2 Partial Correlations Between Sex and Facial Metrics

Partial correlations (controlling for age, weight, and height) between each facial metric and sex in heterosexual subjects only are shown in Table 4.2. There were differences between heterosexual men and heterosexual women for 30 of the 63 facial

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[10] For more details, contact the first author at ms10yp@brocku.ca.

[11] Note that an alternative strategy would be to statistically control for body mass index (BMI) and age in the analyses. Given that height ($B = -0.29$, $SE = .003$, $t = -88.48$, $p < .001$) and weight ($B = .34$, $SE = .002$, $t = 161.22$, $p < .001$) predicted 98.5% of the variance in BMI ($R = .99$, $R^2 = .98$, $F(2) = 13008.27$, $p < .001$), and there continue to be conceptual problems with the use of BMI (e.g., BMI takes weight into account more than height) (Anderson, 2012; Ernsberger, 2012), we chose to conduct our analyses with our original plan of controlling for height and weight (in addition to age).

metrics. The metric of shape (masculine-feminine dimension) showed the largest effect size, such that heterosexual women had more feminine face shapes than heterosexual men, consistent with the literature (Yamaguchi, et al., 1995).

**4.3.3 Partial Correlations Between Sexual Orientation and Facial Metrics in Women**

Partial correlations (controlling for age, weight, and height) between each metric and sexual orientation, within each sex, are shown in Table 4.2. In women, the partial correlations indicated that there were significant differences between lesbian and heterosexual women for 17 of the 63 facial metrics (see Table 4.2). The greatest difference between lesbian and heterosexual women was on the mouth retracted metric, such that heterosexual women had a more retracted mouth than lesbian women. With respect to the shape metric’s partial correlation with sexual orientation, heterosexual women had more feminine face shapes than lesbian women. Ten of the 17 facial metrics were in the direction of more masculine in lesbian than in heterosexual women, whereas two were in the direction of more feminine in lesbian than in heterosexual women. Five of the 17 facial metrics that were associated with sexual orientation within women were unrelated to sex differences.

**4.3.4 Partial Correlations Between Sexual Orientation and Facial Metrics in Men**

In men, the partial correlations (controlling for age, weight, and height) indicated that there were significant differences between gay and heterosexual men for 11 of the 63 facial metrics (see Table 4.2). The greatest difference was on the nose long metric, such that heterosexual men had longer noses than gay men. With respect to the shape metric’s partial correlation with sexual orientation, there was no significant difference in the shape of the face between gay and heterosexual men. Five of the 11 facial metrics were in the direction of more feminine in gay than in heterosexual men, whereas one was in the direction of more masculine in gay than in heterosexual men. Five of the 11 facial metrics that were associated with sexual orientation within men were unrelated to sex differences.

**4.3.5 Selection of Facial Metrics in Women and Men for Main Analyses**

Of the 17 facial metrics that were partially correlated with sexual orientation within women, 11 were included in the main analyses (see Method section for a description of how the facial metrics were selected within each featural category). These 11 facial metrics were: (1) shape, (2) cheeks: convex, (3) chin: deep, (4) eyes: up, (5) face: brow-nose-chin ratio, (6) forehead: large, (7) mouth: lips inflated, (8) mouth: lips retracted, (9) mouth: retracted, (10) mouth: thin, and (11) nose: up. Seven differed between heterosexual men and women ((1) shape, (2) chin: deep, (3) eyes: up, (4) face: brow-nose-chin ratio, (5) forehead: large, (6) mouth: thin, and (7) nose: up); all seven were in the direction of more masculine for lesbian women (see Table 4.2).

Of the 11 facial metrics that were partially correlated with sexual orientation within men, six were included in the main analyses (see Methods section). These six facial metrics were: (1) cheekbones: high, (2) cheeks: convex, (3) eyes: tilt outward, (4) forehead: tilt back, (5) mouth: retracted, and (6) nose: long. Two differed between heterosexual men and women (cheekbones: high and nose: long); both were in the direction of more feminine for gay men (see Table 4.2).

**4.3.6 Main Analyses in Women**

When the residuals of the 11 facial metrics were entered into a binary logistic regression as simultaneous predictors of sexual orientation in women ($n$ = 186), the first model significantly predicted sexual orientation; $\chi^2 = 50.10$, $p < .001$, *Nagelkerke* $R^2$ = .34 ($d$ = 1.44). The model accurately predicted sexual orientation in 81% of the cases. The strongest unique predictors were shape ($B$ = -0.49, *Wald* = 3.98, $p$ = .05, $OR$ = 0.61, $d$ = 0.27), nose: up ($B$ = 0.58, *Wald* = 4.23, $p$ = .04, $OR$ = 1.78, $d$ = 0.32), mouth: retracted ($B$ = -0.76, *Wald* = 3.66, $p$ = .06, $OR$ = 0.47, $d$ = 0.42), and forehead: large ($B$ = -0.46, *Wald* = 3.21, $p$ = .07, $OR$ = 0.63, $d$ = 0.26). All other predictors were non-significant (*p*s > .16). When only these four predictors were used, the overall final model was significant ($\chi^2$ = 43.50, $p$ < .001, *Nagelkerke* $R^2$ = .30, $d$ = 1.31), the model accurately classified 81% of cases, the nose: up ($B$ = 0.49, *Wald* = 5.56, $p$ = .02, $OR$ = 1.63, $d$ = 0.27), mouth: retracted ($B$ = -0.86, *Wald* = 11.64, $p$ = .001, $OR$ = 0.42, $d$ = 0.48), and forehead: large ($B$ = -0.45, *Wald* = 4.37, $p$ = .04, $OR$ = 0.64, $d$ = 0.25) predictors were significant, and the shape predictor was marginally significant ($B$ = -0.40, *Wald* = 3.39, $p$ = .07, $OR$ = 0.67, $d$ = 0.22).

Thus, lesbian women had noses that were more turned up, had mouths that were more puckered, had smaller foreheads, and had marginally more masculine face shapes than heterosexual women. Recall that in terms of features that showed evidence of typical sex differentiation, heterosexual women had more feminine face shapes, had noses that were more turned down, and had smaller foreheads than heterosexual men (see Table 4.2). Thus, the facial structure of lesbian women demonstrated some atypical sexual differentiation (i.e., had metrics in the same direction as heterosexual men) for two out of the four metrics (shape and nose). The facial structure of lesbian women also exhibited some typical sexual differentiation for one metric (forehead) and exhibited differences that were unrelated to sexual differentiation for one metric (mouth) (for a summary of the results in women, see Table 4.3). The four metrics in the final logistic regression were

Table 4.3. Summary of results of correlational analyses and logistic regressions (final models).

| Facial Metric | Results (versus Heterosexual Counterparts) |
| --- | --- |
| Women: Unique Facial Metrics | |
| Shape: feminine | Lesbian women had marginally more masculine face shapes [a] |
| Nose: up | Lesbian women had noses that were turned up [a] |
| Mouth: retracted | Lesbian women had mouths that were puckered [c] |
| Forehead: large | Lesbian women had small foreheads [b] |
| Women: Additional Facial Metrics Significant at Univariate Level | |
| Cheeks: Convex | Lesbian women had convex cheeks [c] |
| Chin: deep | Lesbian women had shallow chins [a] |
| Eyes: up | Lesbian women had eyes that were up [a] |
| Face: brow-nose-chin ratio | Lesbian women had a large ratio [a] |
| Forehead: tilt back | Lesbian women had foreheads that were tilted back [c] |
| Mouth: Lips inflated | Lesbian women had lips that were inflated [c] |
| Mouth: Lips small | Lesbian women had lips that were large [a] |
| Mouth: Lips retracted | Lesbian women had lips that were protruding [c] |
| Mouth: tilt down | Lesbian women had a mouth that was tilted up [a] |
| Mouth: overbite | Lesbian women had an underbite [a] |
| Mouth: thin | Lesbian women had a mouth that was thick [a] |
| Nose: pointed | Lesbian women had a rounded nose [b] |
| Nose: long | Lesbian women had a short nose [b] |
| Men: Unique Facial Metrics | |
| Nose: long | Gay men had a short nose [a] |
| Cheeks: convex | Gay men had convex cheeks [c] |
| Forehead: tilt-back | Gay men had foreheads that were tilted back [c] |
| Men: Additional Facial Metrics Significant at Univariate Level | |
| Cheekbones: high | Gay men had low cheekbones [a] |
| Eyes: tilt outward | Gay men had eyes tilted outward [c] |
| Mouth: Lips small | Gay men had large lips [b] |
| Mouth: Lips retracted | Gay men had protruding lips [c] |
| Mouth: retracted | Gay men had a protruding mouth [c] |
| Nose: bridge deep | Gay men had a shallow nose bridge [a] |
| Nose: pointed | Gay men had a rounded nose [a] |
| Nose: nostrils large | Gay men had small nostrils [a] |

[a] Atypical sexual differentiation.
[b] Typical sexual differentiation.
[c] Unrelated to sexual differentiation.

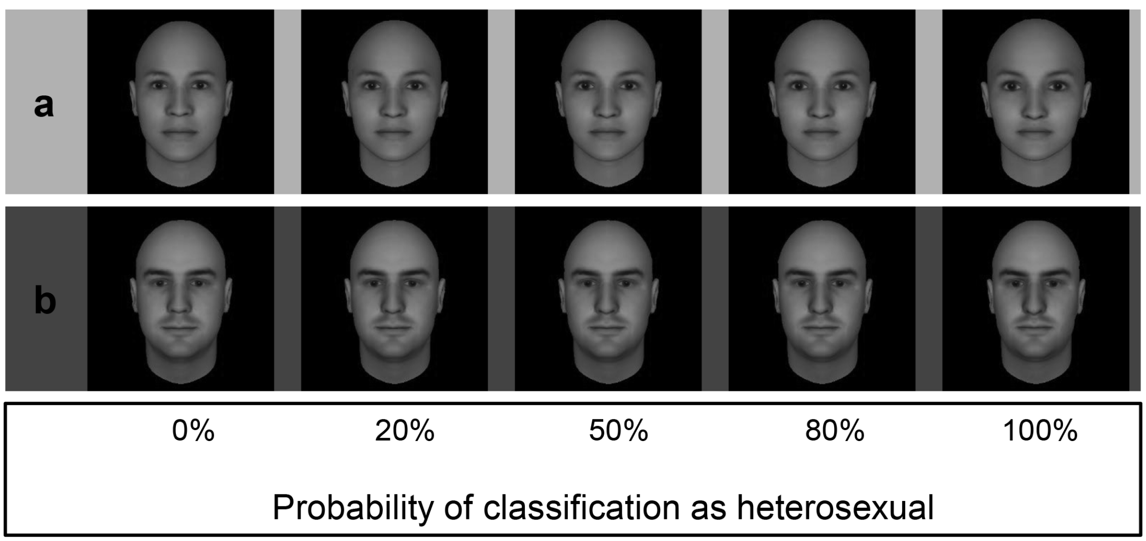
used to generate a facial model of women's sexual orientation (see Fig. 4.1a for the facial model with these four structural differences in women).

**4.3.7 Main Analyses in Men**

For men ($n$ = 204), when the residuals of the six metrics were entered into a binary logistic regression as simultaneous predictors, the first model significantly predicted sexual orientation; $\chi^2$ = 34.60, $p$ < .001, *Nagelkerke* $R^2$ = .21 ($d$ = 1.03). The model accurately predicted sexual orientation in 72% of the cases. The strongest unique predictors were nose: long ($B$ = -0.51, *Wald* = 7.76, $p$ < .01, $OR$ = 0.60, $d$ = 0.28), cheeks: convex ($B$ = 0.38, *Wald* = 3.47, $p$ = .06, $OR$ = 1.46, $d$ = 0.21), and forehead: tilt-back ($B$ = 0.31, *Wald* = 3.36, $p$ = .07, $OR$ = 1.37, $d$ = 0.17). When only these three predictors were used, the final model was again significant ($\chi^2$ = 29.10, $p$ < .001, *Nagelkerke* $R^2$ = .18, $d$ = 0.94), the model accurately classified 67% of cases, and each predictor was significant (nose: long, $B$ = -0.63, *Wald* = 13.74, $p$ < .001, $OR$ = 0.53, $d$ = 0.35; cheeks: convex, $B$ = 0.46, *Wald* = 7.39, $p$ = .007, $OR$ = 1.58, $d$ = 0.25; forehead: tilt-back, $B$ = 0.35, *Wald* = 4.76, $p$ = .029, $OR$ = 1.42, $d$ = 0.19).

Thus, gay men had more convex cheeks, shorter noses, and had foreheads that were more tilted back relative to heterosexual men. Recall that in terms of features that showed evidence of typical sex differentiation, heterosexual men had longer noses than heterosexual women (see Table 4.2). Thus, the facial structure of gay men demonstrated some evidence of atypical sexual differentiation (i.e., had metrics in the same direction as heterosexual women) for one out of the three metrics (nose). The facial structure of gay men also exhibited differences that were unrelated to sexual differentiation for two metrics (cheeks and forehead) (for a summary of the results in men, see Table 4.3). The

**Figure 4.1. Facial models of sexual orientation.** A female (a) and a male (b) face were generated randomly using FaceGen and adjusted based on the statistical models predictive of sexual orientation for each sex. The faces in the centre were adjusted on the relevant metrics identified in the second regression analyses (4 metrics in women, 3 in men) to resemble faces that were most ambiguous with respect to predicted sexual orientation. Faces to the right of centre were adjusted to exaggerate features predictive of a heterosexual orientation whereas those to the left were adjusted to minimize these features. The numbers below the faces represent the statistical probability of being classified as heterosexual by the model for each sex. Faces within the 20-80% range are difficult to discriminate among, indicating that features predictive of sexual orientation may be subtle and that classification accuracy likely depends on structural differences between faces located at the extreme ends of the distribution.



three metrics used in the final logistic regression were used to generate a facial model of men's sexual orientation (see Fig. 4.1b for the facial model with these three structural differences in men).

**4.3.8 Principal Components Analysis (PCA)**

When a PCA was conducted ($n$ = 390) on the 63 facial metrics (again after partialling age, height, and weight), 19 components were extracted (see Table 4.4 for a list of the components and their loadings), which accounted for 85.45% of the variability in the facial metrics. Point-biserial correlations between sex and the component scores for the 19 components revealed six components on which heterosexual women differed from heterosexual men (as indicated by superscripts in Table 4.4). These were Components 1 ($r$ = .20, $p$ = .001), 6 ($r$ = .26, $p$ < .001), 12 ($r$ = .14, $p$ = .02), 13 ($r$ = .20, $p$ = .001), 14 ($r$ = -.12, $p$ = .05), and 16 ($r$ = -.25, $p$ < .001). The greatest difference between heterosexual men and heterosexual women was on Component 6, which was comprised of several nose metrics, and on Component 16, which was comprised of the face shape metric.

When the scores for the 19 components were entered as simultaneous predictors of sexual orientation in women ($n$ = 186) in a binary logistic regression, the model was significant ($\chi^2$ = 61.96, $p$ < .001, *Nagelkerke* $R^2$ = .41, $d$ = 1.67) and accurately predicted 83% of cases; Component 1 ($B$ = 0.83, *Wald* = 8.90, $p$ = .003, *OR* = 2.29, $d$ = 0.46), Component 5 ($B$ = -1.06, *Wald* = 14.60, $p$ < .001, *OR* = 0.35, $d$ = 0.58), Component 6 ($B$ = -0.48, *Wald* = 5.02, $p$ = .03, *OR* = 0.62, $d$ = 0.26), Component 15 ($B$ = -0.58, *Wald* = 6.64, $p$ = .01, *OR* = 0.56, $d$ = 0.32), and Component 16 ($B$ = -0.46, *Wald* = 3.72, $p$ = .05, *OR* = 0.63, $d$ = 0.26) were significant predictors (all other $p$s > .05).

Table 4.4. Varimax-rotated component matrix from the principal components analysis for the total sample ($n$ = 390).

| Facial Metrics | Component | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| *Component 1* (11.05%)[b] | | | | | | | | | | | | | | | | | | | |
| Mouth-Chin Distance: long | **-.87** | | | | | | | | | | | | | | | | | | |
| Mouth: tilt down | **-.86** | | | | | | | | | | | | | | | | | | |
| Mouth: overbite | **-.85** | | | | | | | | | | | | | | | | | | |
| Mouth: down | **.79** | .33 | | | | | | | | | | | -.39 | | | | | | |
| Mouth: pursed | **.68** | | | | .57 | | | | | | | | | | | | | | |
| Face: short | **-.63** | | | .52 | | | | | | -.42 | | | | | | | | | |
| Cheeks: gaunt | **.63** | | | | | | | | | | | | | | | | | | |
| Mouth: Lips thick | **.52** | | -.33 | | | | | | | | | | | .34 | .32 | | | | |
| Cheeks: convex | **.49** | | | -.37 | | | | | | | | | | | -.31 | -.32 | | | |
| Chin: deep | **-.41** | | | | | | | | | | | | | | | | .37 | .41 | |
| *Component 2* (7.30%) | | | | | | | | | | | | | | | | | | | |
| Nose: nostril tilt up | | **.89** | | | | | | | | | | | | | | | | | |
| Nose: bridge long | | **-.88** | | | | | | | | | | | | | | | | | |
| Nose: up | | **.83** | | | | | | | | | | | | | | | | | |
| Nose: tilt up | | **.80** | | | | .31 | | -.35 | | | | | | | | | | | |
| *Component 3* (6.77%) | | | | | | | | | | | | | | | | | | | |
| Jaw: jutting | | | **.96** | | | | | | | | | | | | | | | | |
| Chin: jutting | | | **.96** | | | | | | | | | | | | | | | | |
| Chin: backward | | | **-.68** | | | | | | -.36 | | | | | | | | | | |
| Chin: thin | | | **.64** | | | | | | | | | | | | | | -.40 | | |
| Chin: recessed | | | **-.64** | | | | | | .61 | | | | | | | | | | |
| *Component 4* (6.31%) | | | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brow Ridge: low | | | | **.95** | | | | | | | | | | | | | | |
| Brow Ridge Inner: up | | | | **-.91** | | | | | | | | | | | | | | |
| Brow Ridge Outer: down | | | | **.77** | | | | | | | | | | | | | | |
| Face: down | | | | **.61** | | | | | | -.59 | | | | | | | | |
| *Component 5* (5.98%) | | | | | | | | | | | | | | | | | | |
| Mouth: Lips inflated | | | | | **-.96** | | | | | | | | | | | | | |
| Mouth: Lips small | -.41 | | | | **.85** | | | | | | | | | | | | | |
| Mouth: sad | .35 | | | | **.65** | | | | | | | | | -.40 | | | | |
| Mouth: thin | | | | | **.55** | | | -.40 | | | | | | .41 | | | | |
| Mouth: retracted | -.40 | | | | **.51** | .35 | | .41 | | | | | | | | | | |
| *Component 6* (5.51%) [b] | | | | | | | | | | | | | | | | | | |
| Nose: long | | | | | | **.91** | | | | | | | | | | | | |
| Nose: bridge deep | | | | | | **.75** | | .31 | | | | | | | | | | |
| Nose: pointed | | .51 | | | | **.75** | | -.36 | | | | | | | | | | |
| Nose: nostrils large | | .55 | | | | **.64** | | | | | | | | | | | | |
| *Component 7* (5.06%) | | | | | | | | | | | | | | | | | | |
| Face: thin | | | | | | | **.81** | | | | | | | | | | | |
| Eyes: together | | | | | | | **.80** | | | | | | | | | | | |
| Cheekbones: wide | | | .32 | | | | **.62** | | | | | | | | | | | |
| Temples: wide | | | | | | | **.58** | | | | | | | | | | | |
| Forehead: tilt back | | | | | | | **-.57** | | | | | | | | | | | .39 |
| *Component 8* (4.66%) | | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nose: region convex | | | | | | | | **-.78** | | | | | | | | | | | |
| Nose: sellion deep | | | | | | | | **.64** | | | | | | | | | | | .33 |
| Nose: sellion deep | | | | | | | | **.60** | | | | .39 | | | | | | | |
| *Component 9* (4.19%) | | | | | | | | | | | | | | | | | | | |
| Jawline: convex | | | | | | | | | **.78** | | | | | | | | | | |
| Chin: short | .37 | | | | | | | | **.77** | | | | | | | | | | |
| *Component 10* (3.72%) | | | | | | | | | | | | | | | | | | | |
| Eyes: up | .45 | | | | | | | | | **.73** | | | | | | | | | |
| Forehead: short | | | | | | | | | | **.67** | | | | | | | | | |
| Cheekbones: high | | | | | | | | | | **.50** | | .31 | | | | | | | |
| *Component 11* (3.59%) | | | | | | | | | | | | | | | | | | | |
| Head: thin | | | | | | | | | | | **.86** | | | | | | | | |
| Facial Width-to-height Ratio | | | | | | | | | | | **.78** | | | | | | | | |
| Face: light | .36 | | | | | | | | | | **-.47** | | | | | | | | |
| *Component 12* (3.54%) [b] | | | | | | | | | | | | | | | | | | | |
| Nose: sellion wide | | | | | | | | | | | | **.83** | | | | | | | |
| Eyes: large | | | | | | | .36 | | | | | **-.66** | | | | | | | |
| Nose: sellion up | | -.32 | | | | | | | | | | **-.66** | | | | | | | |
| *Component 13* (3.17%) [b] | | | | | | | | | | | | | | | | | | | |
| Face: brow-nose-chin ratio | | | | | | | | | | | .34 | | **.78** | | | | | | |
| Mouth: Lips retracted | | | .42 | | .40 | .31 | | | | | | | **-.65** | | | | | | |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jaw-Neck-Slope: low | | | | | | | | | .32 | | | | **.36** | | | | | | -.30 |
| *Component 14* (2.94%) [a] | | | | | | | | | | | | | | | | | | | |
| Cheekbones: pronounced | | | | | | | | | | | | | | **.66** | | | | | |
| Face: gaunt | | | | | | -.31 | | | | | | | | **.44** | | -.36 | | | |
| Jaw: thin | -.31 | | | | | | | | | | | | | **-.36** | | | | | |
| *Component 15* (2.54%) | | | | | | | | | | | | | | | | | | | |
| Forehead: large | | | | | | | | | | | | | | | **.67** | | | | |
| Nose: nostrils thin | | | -.39 | | | | | | | | | | | | **.49** | .30 | | | |
| *Component 16* (2.50%) [a] | | | | | | | | | | | | | | | | | | | |
| Shape: feminine | | | | | | | | | | | | | | | | **.86** | | | |
| *Component 17* (2.47%) | | | | | | | | | | | | | | | | | | | |
| Chin: large | .30 | | | | | | | | | | | | | | | | **.78** | | |
| *Component 18* (2.09%) | | | | | | | | | | | | | | | | | | | |
| Face: forehead-sellion-nose ratio | | | | | | | | | | | | | | | | | | **.77** | |
| *Component 19* (2.09%) | | | | | | | | | | | | | | | | | | | |
| Eyes: tilt outward | | | | | | | | | | | | | | | | | | | **.75** |

*Note*. Numbers in parentheses indicate the proportion of variance accounted for by each component. Boldface font is used to indicate which variables belong to each component. For simplification of display, loadings < .30 are not shown.

[a] Heterosexual women had significantly higher scores on this component than did heterosexual men (*p*s < .05).

[b] Heterosexual men had significantly higher scores on this component than did heterosexual women (*p*s < .05).

With only these five components as simultaneous predictors of sexual orientation in women, the model was again significant ($\chi^2 = 46.72$, $p < .001$, *Nagelkerke* $R^2 = .32$, $d = 1.37$) and accurately predicted 83% of cases; Component 1 ($B = 0.72$, *Wald* = 8.79, $p = .003$, $OR = 2.06$, $d = 0.40$), Component 5 ($B = -0.94$, *Wald* = 15.86, $p < .001$, $OR = 0.39$, $d = 0.52$), Component 6 ($B = -0.43$, *Wald* = 4.54, $p = .03$, $OR = 0.65$, $d = 0.24$), and Component 15 ($B = -0.69$, *Wald* = 9.79, $p = .002$, $OR = 0.50$, $d = 0.38$) were significant, but Component 16 ($B = -0.32$, *Wald* = 2.41, $p = .12$, $OR = 0.73$, $d = 0.17$) was no longer significant. Thus, linear combinations of several facial metrics discriminated between heterosexual and lesbian women. Heterosexual women had higher component scores than lesbian women on Components 5, 6, and 15, and had lower scores than lesbian women on Component 1. Component 1 was defined by mouth, cheek, depth of chin, and length of face metrics. Component 5 was defined by several mouth metrics and Component 6 was defined by several nose metrics. Component 15 was defined by the size of the forehead and width of the nostrils. Recall that heterosexual women had lower scores on Component 1 and 6 than heterosexual men. Thus, the facial structure of lesbian women was consistent with atypical sexual differentiation for Component 1 (i.e., more masculine), some typical sexual differentiation for Component 6 (i.e., more feminine), and exhibited differences that were unrelated to sexual differentiation for Components 5 and 15.

When the 19 components were entered as simultaneous predictors of sexual orientation in men ($n = 204$) in a binary logistic regression, the model was significant ($\chi^2 = 30.78$, $p = .04$, *Nagelkerke* $R^2 = .19$, $d = 0.97$) and accurately predicted 70% of cases; only Component 6 ($B = -0.75$, *Wald* = 18.25, $p < .001$, $OR = 0.47$, $d = 0.42$) was a significant predictor (all other *p*s > .05). With only Component 6 as a predictor of sexual orientation in men, the model was again significant ($\chi^2$ = 21.39, $p < .001$, *Nagelkerke* $R^2$ = .14, $d$ = 0.81), the model accurately predicted 67% of cases, and Component 6 ($B$ = -0.71, *Wald* = 18.49, $p < .001$, *OR* = 0.49, $d$ = 0.39) was a significant predictor. Thus, linear combinations of some (but less than in women) facial metrics discriminated between heterosexual and gay men. Gay men had lower scores than heterosexual men on Component 6, which was defined by several nose metrics. Recall that heterosexual men had higher scores on Component 6 than heterosexual women. Thus, the facial structure of gay men suggested some atypical sexual differentiation for Component 6 (i.e., more feminine).

**4.3.9 Discriminant Functions Analysis (DFA)**

The analysis on the 54 facial metrics (again after partialling out age, height, and weight from each metric) revealed three functions (see Table 4.5). The test of functions revealed that Functions 1 and 2 were significant, whereas Function 3 was marginally significant: Functions 1 through 3 (Wilks' Lambda = .43, $\chi^2$ = 308.05, $df$ = 162, $p < .001$); Functions 2 through 3 (Wilks' Lambda = .61, $\chi^2$ = 178.69, $df$ = 106, $p < .001$); and Function 3 (Wilks' Lambda = .83, $\chi^2$ = 65.95, $df$ = 52, $p$ = .09). For function interpretation, researchers typically consider loadings above .33 meaningful (i.e., 10% of variance; Tabachnick & Fidell, 2007). Based on this convention, Function 1 appeared to represent the extent to which the face had a mouth and lips that were protruding or retracted, a small or large forehead, and a pointed or flat nose. Higher scores indicate less retracted mouth and lips, a smaller forehead, and a flatter nose. From the discriminant functions plot (see Fig. 4.2), it is clear that Function 1 was effective at separating

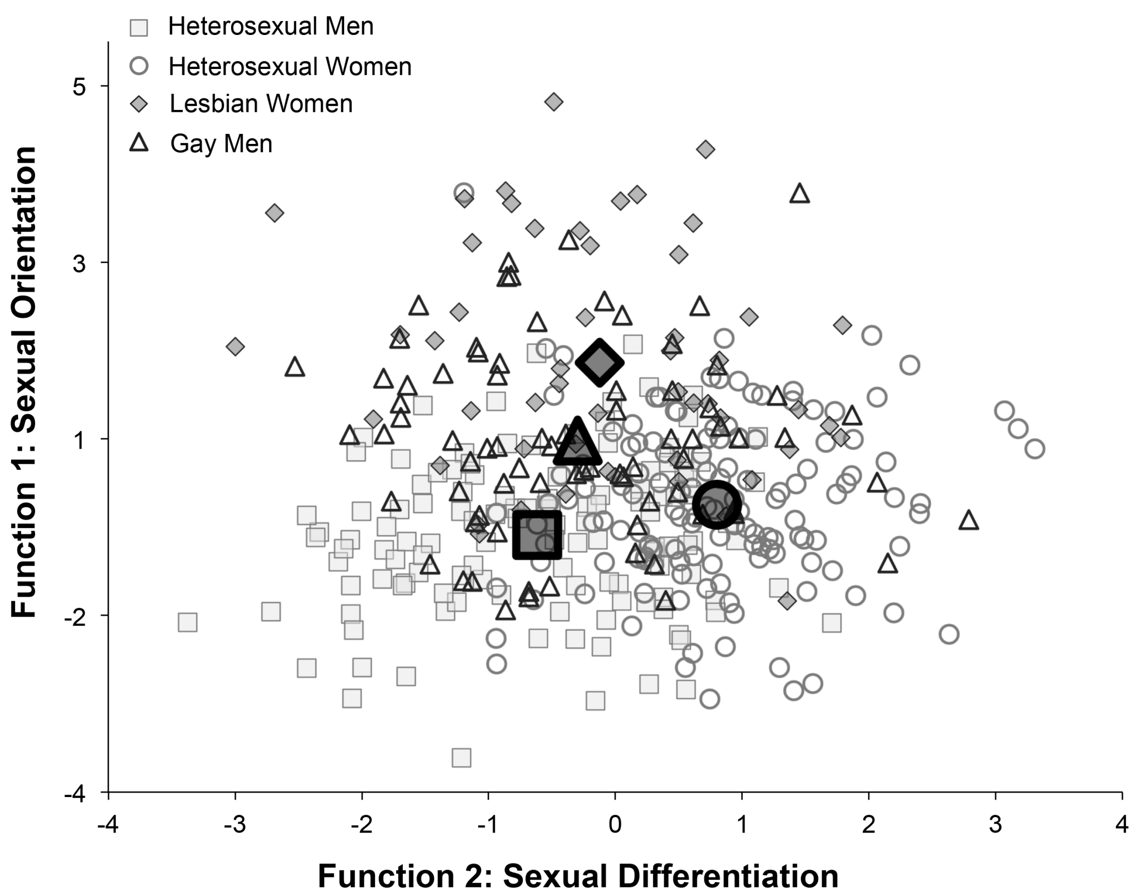
Table 4.5. Structure matrix showing the discriminant functions and corresponding loadings from the discriminant functions analysis for the total sample (*n* = 390).

| | Discriminant Functions | | |
|---|---|---|---|
| Predictors | 1 | 2 | 3 |
| *Function 1* (43.2%; Canonical *r* = .55) | | | |
| Mouth: retracted | **-.48** | .17 | .03 |
| Mouth: Lips retracted | **-.37** | .05 | .07 |
| Forehead: large | **-.34** | .25 | .07 |
| Nose: pointed | **-.33** | -.19 | -.09 |
| Nose: bridge deep | **-.32** | -.21 | -.14 |
| Nose: nostrils large | **-.31** | -.22 | .06 |
| Mouth: Lips inflated | **.30** | -.15 | -.10 |
| Mouth: Lips small | **-.29** | .28 | -.02 |
| Cheeks: convex | **.27** | -.19 | .22 |
| Forehead: tilt back | **.24** | -.14 | .05 |
| Face: gaunt | **.23** | .10 | -.01 |
| Head: thin | **.18** | .08 | -.13 |
| Forehead: short | **.15** | -.15 | .01 |
| Jawline: convex | **.11** | .00 | -.05 |
| Face: down | **-.10** | .04 | -.01 |
| Jaw-Neck-Slope: low | **.08** | -.05 | -.06 |
| Facial Width-to-Height Ratio | **-.06** | .00 | .06 |
| | | | |
| *Function 2* (36.7%; Canonical *r* = .52) | | | |
| Shape: feminine | .01 | **.54** | -.10 |
| Mouth: overbite | -.14 | **.43** | .03 |
| Mouth: tilt down | -.24 | **.35** | .03 |
| Mouth: down | -.06 | **-.32** | .14 |
| Eyes: up | .15 | **-.31** | .02 |
| Eyes: large | .00 | **.30** | .04 |
| Mouth-Chin Distance: long | .07 | **.30** | -.20 |
| Face: brow-nose-chin ratio | .12 | **-.26** | .04 |
| Mouth: thin | -.14 | **.24** | .05 |
| Chin: deep | -.08 | **.24** | .04 |
| Mouth: sad | -.05 | **-.23** | -.02 |
| Face: short | -.06 | **.23** | -.04 |
| Cheeks: gaunt | .08 | **-.22** | .02 |
| Nose: sellion deep | .11 | **-.20** | .15 |
| Cheekbones: pronounced | -.02 | **.18** | .02 |
| Jaw: thin | .03 | **.17** | -.08 |
| Nose: nostril thin | -.08 | **.16** | -.08 |
| Nose: nostril tilt up | -.03 | **-.15** | -.02 |
| Face: thin | -.12 | **.15** | -.02 |
| Chin: short | -.02 | **-.09** | .04 |

| | | | |
|---|---|---|---|
| Face: forehead-sellion-nose ratio | .05 | **.08** | .05 |
| Chin: recessed | -.05 | **-.07** | .02 |
| | | | |
| *Function 3* (20.1%; Canonical *r* = .41) | | | |
| Mouth: Lips thick | .01 | -.23 | **.29** |
| Cheekbones: high | -.11 | -.10 | **-.28** |
| Mouth: pursed | -.12 | -.10 | **.23** |
| Chin: large | .00 | -.10 | **-.19** |
| Chin: thin | -.11 | -.06 | **.17** |
| Brow Ridge Outer: down | -.05 | -.07 | **.15** |
| Eyes: tilt outward | .06 | -.07 | **-.13** |
| Chin: backward | .05 | -.07 | **-.12** |
| Cheekbones: wide | -.08 | .07 | **.11** |
| Eyes: together | -.03 | .04 | **-.10** |
| Jaw: jutting | .06 | .05 | **-.10** |
| Chin: jutting | .06 | .05 | **-.09** |
| Face: light | -.03 | .03 | **.08** |
| Brow Ridge Inner: up | -.04 | -.05 | **-.08** |
| Brow Ridge: low | .01 | -.05 | **.07** |

*Note.* Values represent correlations between each predictor and the corresponding function. Values in boldface font represent the predictor's largest absolute correlation. Numbers in parentheses indicate the proportion of variance accounted for by each function.

**Figure 4.2. Discriminant functions plot of gay men (*n* = 77), lesbian women (*n* = 52), heterosexual men (*n* = 127), and heterosexual women (*n* = 134).** Large data points represent group centroids (the mean value of each groups on each function) from the discriminant functions analysis. Function 1 appears to represent a linear combination of features that differentiate heterosexual men and women from gay men and lesbian women, or a sexual orientation dimension of facial variation that is unrelated to sexual differentiation. Function 2 appears to represent a linear combination of features that best differentiate heterosexual women from heterosexual men, with lesbian women and gay men in between the two heterosexual groups, or a dimension of sexual differentiation. Lesbian women are shifted toward the masculine end of Function 2, and gay men are slightly shifted toward the feminine end of Function 2.



heterosexual men and women from gay men and lesbian women, indicating that it may represent a sexual orientation dimension of facial variation that is unrelated to sexual differentiation.

Function 2 seemed to represent the extent to which the shape of the face is masculine or feminine, and the extent to which the mouth has an overbite or an underbite and is tilted up or down. Higher scores indicate a more feminine shape, a mouth with overbite, and a mouth that is more tilted down. When subjects' scores on Function 2 were plotted along with their scores on Function 1 (see Fig. 4.2), it is clear that Function 2 strongly discriminated heterosexual women from heterosexual men, with lesbian women and gay men in between the two heterosexual groups. Note that lesbian women were shifted toward the masculine end of Function 2 (i.e., as close to heterosexual men as they were to heterosexual women). Gay men were slightly shifted toward the feminine end of Function 2. Thus, Function 2 seems to relate to sexual differentiation. In sum, the two functions provide evidence that is consistent with the results from our main analyses: facial metrics both related to and unrelated to sexual differentiation allow for the discrimination between individuals with gay/lesbian versus heterosexual sexual orientations.

Given Function 3 was not significant ($p$ = .09) and the loadings on Function 3 were less than .33, we did not plot subjects' scores on this function. Overall, the classification rates for the discriminant functions analysis was 66.4% for heterosexual women, 60.6% for heterosexual men, 59.6% for lesbian women, and 46.8% for gay men. The proportion of between-group variance for which each function accounted is shown in Table 4.5.

**4.4 Discussion**

We observed significant relationships among sex, sexual orientation, and facial structure. Within heterosexual subjects, there were significant differences between men and women for 30 of the 63 facial metrics in the univariate analyses, with the metric of overall face shape showing the greatest difference. In the PCA, of the six components on which heterosexual women differed from heterosexual men, the greatest difference was on Component 6 (comprised of several nose metrics) and on Component 16 (comprised of the face shape metric). In the DFA, the largest difference was on Function 2, defined by the nose region and by the shape of the face.

In women, at a univariate level, there were significant differences between lesbian and heterosexual women for 17 of the 63 facial metrics, with 10 of the 17 in the direction of more masculine in lesbian than in heterosexual women (for a summary, see Table 4.3). The greatest difference between lesbian and heterosexual women was on the mouth retracted metric, and lesbian women had more masculine face shapes than heterosexual women. Eleven of the 17 facial metrics were included in the main analyses, and four of these uniquely discriminated between lesbian and heterosexual women. Lesbian women had noses that were more turned up, had mouths that were more puckered, had smaller foreheads, and had marginally more masculine face shapes than heterosexual women. The results from the PCA generally corroborated the main analyses. Heterosexual women had higher component scores than lesbian women on Components 5 (defined by several mouth metrics), 6 (several nose metrics), and 15 (size of the forehead and width of nostrils), and had lower scores than lesbian women on Component 1 (mouth, cheek, depth of chin, and length of face metrics). Thus, the faces of lesbian women and heterosexual women differed in regions of the face related to the nose, mouth, forehead, and to a lesser extent, the shape of the face. Finally, the results of the DFA generally corroborated the results of the logistic regressions and the PCA, with lesbians shifted away from heterosexual women and heterosexual men on Function 1 (defined by mouth, forehead, and nose regions), and shifted toward the masculine end of Function 2 (the nose region and the shape of the face).

In men, at a univariate level, there were significant differences between gay and heterosexual men for 11 of the 63 facial metrics, with five of the 11 in the direction of more feminine in gay than in heterosexual men (for a summary, see Table 4.3). The greatest difference was on the nose long metric, and there was no significant difference in the shape of the face. Six of the 11 facial features were included in the main analyses, and three of these uniquely discriminated between gay and heterosexual men. Gay men had more convex cheeks, shorter noses, and had foreheads that were more tilted back relative to heterosexual men. In addition, the results from the PCA generally corroborated the main analyses. Gay men had lower scores than heterosexual men on Component 6 (defined by several nose metrics). Thus, the faces of gay and heterosexual men differed in regions of the face related to the nose and, to a lesser extent, the cheeks and forehead. Finally, the results of the DFA generally corroborated the results of the logistic regressions and the PCA, with gay men shifted away from heterosexual women and heterosexual men on Function 1, and shifted somewhat toward the feminine end of Function 2.

Our results that gay and heterosexual men differ in facial structure were convergent with the results of Hughes and Bremme (2011) and Valentova et al. (2014).

We extended these two studies by including a somewhat larger sample size of men, by including a sample of women, and providing quantitative analyses of facial structure using photographs that were not obtained from websites. Our quantitative results were partially in line with Valentova et al.'s (2014) qualitative results. In both our quantitative analysis of unique predictors and their qualitative follow-up analysis, it was found that gay men had shorter noses and convex shapes around the mouth or cheek region (i.e., oral cleft in Valentova et al.'s study, cheeks in the current study). Thus, these effects were cross-cultural (i.e., found in Canada and Czech Republic) and were found by independent researchers.

Further, in contrast to other physical differences examined in past research, our results suggest facial structure has a substantial association with sexual orientation, particularly in women. In the current study, the effect sizes for *unique facial metrics* or *components* were similar in size or larger in size than the effect sizes for other physical differences examined in past research (e.g., effect of sexual orientation on height for men [e.g., $d = 0.21$ in Bogaert, 2010]; effect of sexual orientation on handedness for women [$d = 0.36$ in Lalumiere et al., 2000]). The effect sizes for the *overall models* examining sexual orientation and facial structure, however, were substantially larger than the effect sizes for other physical differences examined in past research (i.e., in women, $d = 1.31$ in the main analyses, $d = 1.37$ in the PCA; in men, $d = 0.94$ and $d = 0.81$, respectively). Facial structure may be a relatively important physical difference related to sexual orientation. Thus, the mechanisms underlying variation in facial structure may be particularly important in understanding the development of sexual orientation.

Some of the facial differences between gay/lesbian and heterosexual subjects were consistent with the notion that variation in processes of sexual differentiation is a factor in the formation of sexual orientation (i.e., a feature was more "feminine" in gay men and more "masculine" in lesbian women) (see also Valentova et al., 2014) (see also Table 4.3). Sex differences in facial structure are shaped by surges in sex steroidal hormones at the time of puberty (Enlow, 1982; Verdonck et al., 1999). Thus, it is plausible that pubertal sex hormones may contribute to variation in facial structure according to sexual orientation, although we know of no evidence to support the notion that pubertal hormones are implicated in the development of sexual orientation. Specifically, pubertal fluctuations in hormones may cause the faces of gay and lesbian individuals to differ from heterosexual individuals, but they may not be implicated in the basic neural mechanisms of attraction associated with sexual orientation. Nevertheless, any link between pubertal gonadal function and variation in the face linked to sexual orientation may involve a third factor, such as the greater exposure to stressors of gay men and lesbian women compared to heterosexual men and women (e.g., Saewyc, 2011). Prenatal sex hormones are also considered a basis of sex differences in facial structure (Bulygina et al., 2006; Meindl et al., 2012) and are implicated in the development of sexual orientation (Bao & Swaab, 2011; Hines, 2011). For example, higher prenatal testosterone exposure was related to more masculine faces in terms of the shape of the face in boys (Meindl et al., 2012). Prenatal testosterone levels may be lower in men that are gay as adults, and higher in women that are lesbian as adults, compared to their same-sex heterosexual counterparts, which may affect their facial structure in a sex atypical way.

Some of the facial differences between lesbian and heterosexual subjects were consistent with the possibility that (heightened) typical sexual differentiation is a factor in the formation of sexual orientation (i.e., a feature was more “feminine” in lesbian women) (see also Table 4.3). Prenatal hormones fluctuate during gestation and their effects have been shown to operate during critical/sensitive periods of development (Hines, 2011); however, we know of no other studies on the development of female sexual orientation showing additional evidence of a feminization effect in lesbian women. Also, while there was some evidence of feminization of lesbian women, there was more evidence of masculinization than of feminization of lesbian women in the current study. For example, at the univariate level, 10 of the 17 facial metrics related to sexual orientation in women were in the direction of more masculine in lesbian than in heterosexual women (versus two in the feminine direction).

In men, there was only one difference between gay and heterosexual subjects that was consistent with the possibility that heightened typical sexual differentiation is a factor in the formation of sexual orientation (i.e., a feature was more “masculine” in gay men) (see also Valentova et al., 2014) and it was at the univariate level only (see Table 4.3). Thus, one possibility is that prenatal testosterone levels may be higher in the fetuses of men that are gay as adults during a certain critical period of development, although evidence to support this assertion is limited (cf. Bogaert & Hershberger, 1999). Future studies are required to replicate the current findings and to fully understand the mechanisms involving sex hormones responsible for the differences in facial structure found between gay/lesbian and heterosexual individuals.

The facial features predicting sexual orientation in men were not identical to the facial features predicting sexual orientation in women. Also, stronger effects were exhibited in women than in men. These findings reinforce the idea that sexual orientation develops differently in men and women (e.g., Bogaert & Skorska, 2011; Williams et al., 2000) and that biological factors related to facial structure may be particularly relevant to variation in women's sexual orientation (e.g., Grimbos et al., 2010; Singh, Vidaurri, Zambarano, & Dabbs, 1999).

Other facial differences between gay/lesbian and heterosexual subjects involved features for which there was no significant sex difference (see Table 4.3). These results suggest the importance of additional etiological factors beyond variations in androgen signalling related to prenatal and pubertal sexual differentiation. Such a suggestion is in keeping with growing evidence of the limitations in the ability of prenatal androgens to produce sexual dimorphisms, and evidence that sex chromosomes moderate the influence of androgens (Rice et al., 2012). Further, the development of sexual orientation has been shown to involve factors other than variations in androgen signalling related to sexual differentiation, such as developmental instability, maternal immune response to a fetus, epigenetic, and genetic factors (e.g., Blanchard, 2004; Blanchard & Bogaert, 1996; Bogaert & Skorska, 2011; Hamer, Hu, Magnuson, Hu, & Pattatucci, 1993; Lalumiere et al., 2000; Rice et al., 2012). Facial structure too is affected by factors beyond those related to prenatal and pubertal sexual differentiation, including both genetic and epigenetic factors (Greene & Pisano, 2010; Jelenkovic et al., 2010). The possibility of shared developmental mechanisms in craniofacial growth and in sexual orientation that are not rooted in prenatal and pubertal hormones suggests new research directions.

Another explanation for the finding that some facial differences between gay/lesbian and heterosexual subjects involved features for which there was no significant sex difference could be due to Type II error. For example, previous research has identified that male faces generally have longer and wider jaws, whereas female faces generally have smaller jaws and fuller lips (Burke & Sulikowski, 2010; Rhodes, 2006), but the heterosexual women in our sample had smaller lips, thinner lips, and a thinner mouth than heterosexual men. The mouth region was one of the regions that differed between lesbian and heterosexual women, and we cannot rule out the Type II error explanation conclusively. Future research using the FaceGen program to examine sex differences in facial features of heterosexual individuals may be needed to resolve this discrepancy.

Our evidence of featural differences between gay/lesbian and heterosexual individuals provides insight into the cues that may be used for accurate perceptions of sexual orientation by observers (cf. Valentova et al., 2014). Several studies provide empirical support for sex-based heuristics or stereotypes that guide judgements of sexual orientation (e.g., men's faces perceived to be more feminine were more likely to be judged as gay) (Freeman et al., 2010; Stern et al., 2013) (see also McDermid, Zucker, Bradley, & Maing, 1998 for use of sex-based heuristics/stereotypes in the perception of boys and girls with gender identity disorder). Nevertheless, reliance upon sex-based heuristics in guiding sexual orientation judgements may lead to misjudgements of sexual orientation. For example, judgements of sexual orientation are below chance accuracy for counterstereotypical faces (e.g., gay men with masculine faces and lesbian women with feminine faces) (Freeman et al., 2010). Thus, our finding that the facial features that are related to sexual orientation may not be solely dependent on sexually dimorphic facial features aligns with the finding in the face perception literature that the use of sex-based heuristics partially leads to errors in judgements of sexual orientation. In addition, the better prediction of sexual orientation in women than in men by our statistical model parallels the greater accuracy of observers in determining the sexual orientation of women than of men (Lyons, Lynch, Brewer, & Bruno, 2014; Tabak & Zayas, 2012). Future studies may be able to determine whether the facial metrics identified here and in Valentova et al. (2014) are the basis for judgements of sexual orientation by observers.

The present study was limited in that it did not examine observers' perceptions of sexual orientation based on the facial photographs. Another limitation is our use of a deductive statistical approach. Although we were relatively conservative with selection of facial metrics, we did not have a priori predictions for the specific facial metrics that would differentiate gay/lesbian individuals from heterosexual individuals, which increases the chance of Type I errors. As such, future studies are required to replicate these effects. Future studies should replicate with equal sample sizes across the groups, as unequal sample sizes across groups could introduce bias toward groups with greater dispersion, particularly in discriminant function analysis (Tabachnick & Fidell, 2007). Future studies should also replicate using FaceGen and other facial measuring techniques. For example, error could be introduced when using FaceGen because the faces have to be fitted to the points on the face required by FaceGen to compute the numerical values for each facial metric. We attempted to avoid this source of error by having only the third author fit the faces. Nevertheless, utilizing other techniques that do not require fitting of faces by an individual would be beneficial. Also, future studies are required to further corroborate which facial features are sexually dimorphic, especially using FaceGen. Further, the results cannot generalize to individuals of various ethnicities, given that we only examined White individuals in this study. Also, the results cannot directly address questions of causality or mediating variables in the relationship between sexual orientation and facial structure.

Nevertheless, the findings presented here provide additional evidence for the association of a largely biological factor, facial structure, with sexual orientation. The faces of lesbian and gay individuals differed from their heterosexual counterparts in a number of ways (see Table 4.3). In addition, the overall facial effects associated with sexual orientation (e.g., *d*s associated with the overall models) were large. Thus, this research complements and extends other research on biological factors implicated in the development of sexual orientation, whether these factors are based in fetal androgen signalling or other mechanisms.

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## Chapter 5: General Discussion

### 5.1 Summary and Strengths of the Dissertation

The purpose of this dissertation was to investigate three physical correlates of sexual orientation to determine whether they are reliably associated with sexual orientation. Also, by examining these physical variables and their relation to sexual orientation, insight into the potential mechanisms underlying sexual orientation was gleaned. In Study 1 the height difference between gay men and heterosexual men was replicated in a nationally representative sample of the US, such that gay men were found to be shorter, on average, than heterosexual men. No statistically significant height difference was found between lesbian women and heterosexual women (although means were in the predicted direction). In addition to replicating the height effect, no evidence was found that stress and nutrition at puberty mediated the association between sexual orientation and height in men. Thus, it is unlikely that pubertal stress and pubertal nutrition are implicated in the association between sexual orientation and height, and in the development of sexual orientation generally. The possibility of other mechanisms (e.g., prenatal hormones, genetics) explaining the sexual orientation-height link, and the development of sexual orientation, is thus more likely.

In Study 2 it was found that firstborn gay male only-children had, on average, a significantly lower mean birth weight compared with the mean of firstborn children in four other sibship compositions: gay males with no older brothers, gay males with older brothers, male heterosexual only-children, and heterosexual males with siblings. There were no significant differences in duration of pregnancy between the groups of siblings.

In addition to birth weight, it was found that mothers of gay male only-children reported more fetal loss, on average, compared to mothers of male children with each of the other sibship categories (once total number of pregnancies were controlled for). Low birth weight has been shown to be an indicator of a mother's immune system response to a pregnancy. Immune reactions in mothers have also been implicated in fetal loss, especially with respect to secondary recurrent miscarriage. That is, a maternal immune response seems to affect recurring miscarriages after the birth of one child. This maternal immune response also seems to affect the sexual orientation of the (first) child that is born. Thus, the findings of Study 2 provide support for the idea that a maternal immune response—one that is likely distinct from the maternal immune response hypothesized to be responsible for the traditional fraternal birth order (FBO) effect (i.e., not associated with an elevated number of older brothers)—is also likely implicated in the development of sexual orientation of gay male only-children.

In Study 3 it was found that facial structure was associated with sexual orientation in men and in women. Lesbian and heterosexual women differed in 17 facial features (out of 63 possible facial features that were investigated) at the univariate level. Four of the 17 facial features were unique multivariate predictors. Gay and heterosexual men differed in 11 facial features at the univariate level, and three of these 11 facial features were unique multivariate predictors. The specific unique facial features that differed between gay and heterosexual men were different from the unique facial features that differed between lesbian and heterosexual women. Also, some, but not all, of the facial features differed between the sexes. Thus, the facial features that differed between heterosexual men and heterosexual women, and also differed between lesbian women and heterosexual women, and differed between gay and heterosexual men, implicate a sexual differentiation related mechanism (e.g., prenatal hormones) in the explanation of the sexual orientation-facial structure association, and in the explanation of the development of sexual orientation. On the other hand, the facial features that did not differ between the sexes but differed between lesbian and heterosexual women, and differed between gay and heterosexual men, implicate a non-sexual differentiation related mechanism (e.g., developmental instability) in the explanation of the sexual orientation-facial structure association, and in the explanation of the development of sexual orientation more generally.

In addition to extending our understanding of the mechanisms implicated in the development of sexual orientation in general, the findings add to and extend the empirical literature on the physical correlates associated with sexual orientation. Study 1 is the second study known to date to find an association between sexual orientation and objective height in men (Skorska & Bogaert, 2016; cf. Martin & Nguyen, 2004). The main novelty of Study 1 was, however, the additional mediation analysis and the finding that pubertal stress and pubertal nutrition likely do not mediate the relationship between sexual orientation and height in men, which has not been examined in the research literature to date. The finding in Study 2 on birth weight is a partial replication and extension of the findings of Blanchard (2012) within men and VanderLaan, Blanchard, Wood, Garzon, and Zucker (2015). The additional finding in Study 2 on fetal loss is novel. Study 3 is only the third study known to date to investigate the relationship between sexual orientation and facial structure. Thus, it is a partial replication of previous studies (Hughes & Bremme, 2011; Valentova, Kleisner, Havlicek, & Neustupa, 2014) that have demonstrated this association, but also significantly extends this previous work by demonstrating that both sex-dimorphic and non-sex-dimorphic facial features are relevant to predicting sexual orientation in both men and women.

An additional strength of this dissertation was that three different and unique samples of participants were utilized in the three studies included in this thesis. Study 1 used a very large nationally representative sample of the US: the Add Health data. Also, this sample contained data that was collected longitudinally, with the stress and nutrition related measures collected at Wave I in 1994/1995 and the height measure collected from the same sample of participants at Wave IV in 2008. Study 2 used a cross-sectional convenience sample of mothers of men of various sexual orientations who provided their complete pregnancy histories, as well as the sexual orientation of their children. Study 3 used a large cross-sectional convenience sample of gay, lesbian, and heterosexual participants in which photographs of the faces of participants were taken at various locations across four provinces in Canada (Quebec, Ontario, Alberta, and British Columbia). The use of various samples demonstrates the breadth in research design, in analytical strategies utilized to analyze the data, and in the overall scope of the dissertation.

Also, some of the effect sizes found within the dissertation would be considered moderate to large. The height difference found between gay men and heterosexual men in Study 1 was small ($R^2$ = 2.5%); however, in Study 2, the significantly greater mean ratio of the number of fetal losses to number of live births in mothers of gay only-children compared with the mean of all other mothers translated into a *d* of 1.56 (a large effect). Also, the lower mean birth weight of gay male only-children compared with the mean birth weight of the first-pregnancy males in all other groups translated into a *d* of 1.18 (a

600-g difference; a moderate-to-large effect). In Study 3, the effect sizes for unique facial features were small or moderate in size, but the effect sizes for the overall models examining sexual orientation and facial structure, were large (i.e., in women, $d = 1.31$ in the main analyses, $d = 1.37$ in the principal components analysis; in men, $d = 0.94$ and $d = 0.81$, respectively). Thus, some of the findings included in this dissertation had moderate or large effect sizes, which is not always common in literature examining physical characteristics associated with sexual orientation (see Introduction of Study 1 for some comparisons).

### 5.2 The Bigger Picture

An additional strength of this thesis is the knowledge that is gained about the development of sexual orientation. Three important insights about the development of sexual orientation are supported with the studies included in this dissertation. First, there is a greater likelihood that the mechanisms responsible for the development of sexual orientation (at least those associated with physical characteristics) occur at the prenatal level. Second, there seem to be sex differences in the development of sexual orientation. Third, there are additional mechanisms beyond those rooted in sexual differentiation that are partially responsible for the development of sexual orientation. These insights are elaborated on below.

#### 5.2.1 Prenatal Factors

Some theorists argue for the role of prenatal factors in the development of sexual orientation. For example, prenatal hormone theory posits that it is a differing exposure of sex hormones in the womb (and perhaps at different critical periods of development) that ultimately affects the brain of the developing fetus, which eventually affects the sexual attraction of the individual in adulthood (Ellis & Ames, 1987). Also, the maternal immune hypothesis (proposed to explain the FBO effect) posits that the brain of a male fetus is affected by antibodies developed by the mother against male-specific proteins that a Y chromosome has, particularly after the mother is successively exposed and immunized to these proteins with one or more male pregnancies (Blanchard & Bogaert, 1996; Blanchard & Klassen, 1997).

This thesis provides additional indirect support for the role of prenatal factors with the replication of previous findings, along with extensions to the existing research literature. For example, the lack of mediation of the sexual orientation and height relationship by pubertal stress and pubertal nutrition provides evidence that processes at puberty related to physical development likely do not play a role in the development of sexual orientation. In turn, it can be argued that it is *more likely* that prenatal factors are relevant here, as hypothesized in several of the papers published on the association between sexual orientation and height. Of course, given that these additional prenatal factors were not directly measured, it is difficult to determine exactly which prenatal factors (e.g., prenatal hormones, genetics) are implicated. For example, gay men (relative to heterosexual men) may have been exposed to lower levels of prenatal hormones and/or affected by certain genes that underlie both brain structures related to sexual orientation and to growth and development. Further, in Study 2, the variables that were examined (i.e., birth weight, fetal loss) are, by definition, the result of processes that are occurring in the womb of the mother, and, thus, men's sexual orientation linked to these variables are very likely the result of prenatal mechanisms (Christensen et al., 2012; Hoff, Peevy, Spinnato, Giattina, & Peterson, 1993; Kiefte-de Jong et al., 2013; Kusanovic et al., 2010; Nielsen, 2011; Nielsen et al., 2010; Silver et al., 2011). In Study 3, postnatal, biological factors cannot be ruled out to explain how facial structure develops; however, prenatal factors are also implicated in the development of the face (Bulygina, Mitteroecker, & Aiello, 2006; Meindl, Windhager, Wallner, & Schaefer, 2012), and thus, prenatal mechanism(s) are a good candidate for explaining the association between facial structure and sexual orientation. Overall, the research included in this dissertation provides further evidence for the role of prenatal factors in the development of sexual orientation.

### 5.2.2 Sex Differences

Several research findings in the sexual orientation field suggest that there is likely a sex difference in the development of sexual orientation. For example, the FBO effect has only been demonstrated in men (for reviews, see Blanchard, 2004; Blanchard & VanderLaan, 2015; Bogaert & Skorska, 2011), and thus, the putative maternal immune response mechanism responsible for the FBO effect is hypothesized to be implicated in the development of sexual orientation in men only. Also, the pattern of the findings in the 2D:4D literature provides a second example. In the meta-analysis conducted by Grimbos, Dawood, Burriss, Zucker, and Puts (2010), it was found that lesbian women had a more masculine 2D:4D than heterosexual women; however, heterosexual men did not differ from gay men in 2D:4D. The authors interpreted the finding such that, in women, prenatal hormones likely directly affect sexual orientation, and both 2D:4D and sexual orientation likely depend on the same hormonal influences during development. In men, however, sexual orientation development likely does not depend on the same hormonal influences as the development of 2D:4D (Grimbos et al., 2010).

The research in this thesis further supports the idea that sexual orientation likely develops differently in men compared with women. First, a significant relationship between sexual orientation and height was not found in women, convergent with the findings of most other studies that have investigated sexual orientation and height (e.g., Skorska & Bogaert, 2016; cf. Bogaert, 1998). Thus, it is possible that the mechanism(s) responsible for the sexual orientation-height relationship operate in men only.[12] Further, in Study 3, facial structure was related to sexual orientation in both men and women; however, the pattern of findings and the particular facial features that were found in men were different compared with the pattern of findings and the particular facial features that were found in women. Moreover, stronger effects were found in women than in men. Again, this pattern of findings suggests that the mechanism(s) responsible for the sexual orientation-facial structure relationship are likely different within men compared with the mechanism(s) within women. Assuming that the facial structure differences are rooted in a prenatal mechanism, this pattern of findings also suggests that prenatal biological effects may contribute to women's sexual orientation, despite some research suggesting that women's sexual orientation is more fluid/flexible than men's and also more influenced by cultural factors (e.g., Baumeister, 2000). In sum, this thesis further contributes to the idea that the development of sexual orientation differs between men and women, although the exact mechanisms have not yet been clearly elucidated.

[12] It is also possible that a very large sample of women is required to find an association between sexual orientation and height, as pointed out in the Discussion in Study 1. A meta-analysis on the relationship between sexual orientation and height might help to clarify whether the lack of a significant height effect within women is due to problems with small sample sizes.

### 5.2.3 Non-Sex-Differentiation Mechanisms

Some research on sexual orientation has examined and/or found evidence for non-sex-differentiation related mechanisms likely implicated in the development of sexual orientation. One example concerns the pattern of findings in the meta-analysis on the relationship between sexual orientation and handedness (Lalumiere, Blanchard, & Zucker, 2000). If boys and men are more likely to be non-right-handed than girls and women, then based on prenatal hormone theory, gay men should have decreased levels of non-right-handedness than heterosexual men, and lesbian women should have increased levels of non-right-handedness than heterosexual women. In the meta-analysis the predicted pattern only held up in women, such that lesbian women were 91% more likely than heterosexual women to be non-right-handed, whereas gay men were 34% more likely than heterosexual men to be non-right-handed (Lalumiere et al., 2000). The authors concluded that developmental instability is likely the best explanation that can account for the findings in both sexes, and it is one example of a mechanism that is not rooted in sexual differentiation.

Developmental instability can be defined as the degree of genetic or environmental stress that can be experienced by an organism during development. Common measures of developmental instability in adults are non-right-handedness and fluctuating asymmetry (i.e., deviations from perfect symmetry of bodily features). Since Lalumiere and colleagues' (2000) meta-analysis some further support has been provided for the association of sexual orientation to handedness and fluctuating asymmetry, although the findings have been mixed (e.g., Ellis, Skorska, & Bogaert, 2016; Lippa, 2003; Martin, Puts, & Breedlove, 2008; Miller, Hoffman, & Mustanski, 2008; Mustanski, Bailey, & Kaspar, 2002; Schwartz, Kim, Kolundzija, Rieger, & Sanders, 2010).

In addition to the handedness finding, a second group of findings suggests that non-sex-differentiation mechanisms are operating in the development of sexual orientation. Some of the physical correlates have been found to interact with FBO in the prediction of sexual orientation within men. Blanchard, Cantor, Bogaert, Breedlove, and Ellis (2006), as well as Bogaert, Blanchard, and Crosthwait (2007), found an interaction between FBO and handedness in the prediction of sexual orientation in men, such that older brothers increased the odds of same-sex attraction only in men who were right-handed. Further, Bogaert (2007) found that older brothers increased the odds of same-sex or both-sex attraction only in men who were moderately right-handed, but older brothers did not increase the odds of same-sex or both-sex attraction in men who were non-right-handed and extremely right-handed. Blanchard (2008) speculated that non-right-handed men with no older brothers have increased odds of same-sex orientation because their brains are less lateralized. Therefore there is a greater chance of connections between neurons in the two hemispheres, which also predisposes these men to a same-sex attraction. Further, Blanchard (2008) hypothesized that older brothers do not have any effect on the chances of same-sex attraction in non-right-handed men because either the fetuses of men who are non-right-handed are insensitive to the presence of maternal anti-male antibodies, or the mothers of male fetuses who are non-right-handed do not produce anti-male antibodies. Blanchard's (2008) hypotheses await testing, although this does not discount the interaction findings in men.

Examining 2D:4D, fraternal birth order, and sexual orientation, Williams and colleagues (2000) found that gay men who had more than one older brother were more likely to have a more masculine right-hand 2D:4D compared to gay men who had no older brothers, whereas there was no difference in right-hand 2D:4D between heterosexual men who have no older brothers or who have more than one older brother. In women, right-hand 2D:4D in lesbian women was more masculine compared to heterosexual women, with no interaction with birth order. The results provide some support for the role of masculinization in lesbian women (relative to heterosexual women), and hyper-masculinization in gay men (relative to heterosexual men) who have greater than one older brother. Likewise, Bogaert and Liu (2006) found an interaction between height and FBO in men, such that as the number of older brothers increases, the discrepancy in height between gay and heterosexual men also increases (i.e., gay men are even shorter and heterosexual men are even taller). Bogaert and Liu (2006) hypothesized that the maternal immune response to male fetuses would also affect growth, in addition to the sexual orientation of the men. Thus, the research conducted on interactions between physical characteristics associated with sexual orientation and FBO have suggested that the development of sexual orientation likely involves multiple pathways beyond the simple role of prenatal hormones in feminizing gay men and masculinizing lesbian women.

In the current thesis, two findings add further support to the idea that non-sex-differentiation mechanisms are implicated in the development of sexual orientation. First, the birth weight and fetal loss findings suggest that there is a second type of maternal immune response that is occurring in the development of sexual orientation. This second maternal immune response is likely distinct from the maternal immune response hypothesized to explain the FBO effect in men, and may also apply to women's sexual orientation (e.g., Blanchard, 2012) although women were not investigated in the sample utilized in Study 2. In addition to Study 2, in Study 3 the facial features that were implicated within men and within women were not always related to gender differences in these facial features (see also Valentova et al., 2014), which suggests that a non-sex-differentiation related mechanism is likely to at least partly explain the association between sexual orientation and facial structure. For example, developmental instability and/or genetic factors unrelated to sexual differentiation may impact facial features and brain structures related to the development of sexual orientation. Thus, the findings included in the current dissertation suggest that the mechanism(s) involved in the development of sexual orientation are likely partially rooted in non-sex-differentiation mechanisms.

### 5.3 Limitations of the Dissertation

Despite the insights gained and the additional knowledge added to the sexual orientation literature, the studies in this dissertation are not without limitations. With the exception of Study 1, the potential mechanisms that are hypothesized to explain the associations between sexual orientation and the physical characteristics included in this dissertation have not been directly measured. Even in Study 1 only two potential explanations were measured (i.e., pubertal stress and pubertal nutrition), but no other potential explanatory mechanisms were measured. Thus, any mechanisms hypothesized to play a role in the development of sexual orientation are speculative and wait further research.

Also, related to the previous point about the mechanisms implicated in the development of sexual orientation, the data in this thesis were limited in that they cannot clearly establish a causal direction in the association between sexual orientation and the physical correlates. Much of the sexual orientation research is limited by this problem because several of the theories proposed to explain the development of sexual orientation are prenatally focused. Because of their prenatal focus, it would be extremely difficult (i.e., time consuming and expensive) and potentially unethical to examine the mechanisms directly, although examining the prenatal mechanisms using certain methodology could begin to address the causal direction (i.e., longitudinal methodology). Study 1 did use a longitudinal data set, but the Add Health data is still limited to the developmental period studied (i.e., puberty) and it is not experimental. In sum, we still do not know exactly whether sexual orientation leads to a certain facial structure, birth weight, and height; whether a certain facial structure, birth weight, and height causes a certain sexual orientation; and/or whether a third variable explains the link between sexual orientation and facial structure, birth weight, and height.

## 5.4 Future Directions

A very ambitious twenty-to-thirty-year longitudinal study measuring potential mechanisms (e.g., prenatal stress, prenatal hormones), physical characteristics (e.g., birth weight, height, handedness, facial structure, 2D:4D), and sexual orientation throughout development in a sample of children would be helpful in further elucidating some of the ways the theorized mechanisms are involved in the development of sexual orientation. In particular, such a study could help with teasing apart some questions regarding the causal directions of the relationships among these various variables. An ambitious study of this kind would be difficult to conduct, however, because, as mentioned, it would require much investment both financially and physically (i.e., the amount of time and energy required to conduct such a study, especially with respect to obtaining a large enough sample size to investigate several correlates across multiple waves of data).

Until then, some additional cross-sectional research would be helpful. Such research would continue to replicate the research findings on the various physical characteristics. In addition, one interesting way to move the field forward would be to start investigating the physical characteristics together (i.e., examined within the same individuals) in a multivariate context. Although some studies have examined multiple correlates (e.g., FBO and height or FBO and birth weight; e.g., Bogaert & Liu, 2006; VanderLaan et al., 2015), the physical correlates have often been studied in isolation. The isolated study of the physical correlates has led to an enumeration of a wide range of different correlates (e.g., handedness, height, birth weight, 2D:4D finger ratios, facial structure, etc.). Such research on isolated correlates has also elucidated a variety of potentially separate mechanisms that may be involved in the development of sexual orientation (e.g., developmental instability, prenatal hormones). It would be interesting to examine, however, if and how the various correlates relate to each other.

If a significant correlation is found between some of the physical characteristics, this association might suggest that the shared mechanism contributing to their development is a potential way that sexual orientation develops. If a non-significant correlation is found between some of the physical characteristics, this lack of association might suggest that the non-shared mechanisms contributing to their development suggests potential independent pathways to the development of sexual orientation. For example, examining the associations between birth weight and facial structure, or between birth weight and height, might help to further specify whether there is a shared mechanism between these variables. If so, this shared mechanism may contribute to the development of sexual orientation. Also, by examining the facial features that are rooted in sexual differentiation (*vs*. the facial features that are not rooted in sexual differentiation) and their association with birth weight and height, we might also glean information about whether the shared mechanisms are rooted in sexual differentiation or not. Investigating the association between low birth weight (given its linkage to an immune mechanism) and other physical characteristics can also help determine whether an immune mechanism is implicated in the association between these other physical characteristics and sexual orientation. Thus, by investigating multiple physical correlates in one sample of individuals we can learn more about the origins of sexual orientation on a broad level, but also gain greater insight into the specific mechanisms involved in the association between sexual orientation and each of the physical correlates, including birth weight, height, and facial structure.

One additional interesting future avenue of research includes measuring sexual orientation, height, and the length of the long bones in the arms and legs. Martin and Nguyen (2004) found that gay men had shorter long bones of the body (in the arms, legs, and hands) than heterosexual men, but they did not find a height difference between gay men and heterosexual men (means were, however, in the expected direction). Also, lesbian women had longer long bones of the body than heterosexual women, and there was no height difference between lesbian women and heterosexual women (but again, means were in the expected direction). The length of long bones and height can be easy to measure, and an added incentive is that long bones can provide more information about the mechanism responsible for the association between height and sexual orientation. Long bones of the arms and legs grow before puberty and are partially responsible for the accelerated growth seen during that time in development (see Martin & Nguyen, 2004 for a review). Thus, the findings of Martin and Nguyen (2004) involving the long bones suggest that a mechanism that occurs before puberty is responsible for the association between sexual orientation and height. However, Martin and Nguyen's long bone finding should be replicated given that theirs is the only known published study on this physical characteristic and its association with sexual orientation, and given that they did not find the predicted height difference. If both the height and long bone differences between gay men and heterosexual men, and between lesbian women and heterosexual women, emerge in a new sample (and especially a very large sample of women), additional evidence of a pre-pubertal mechanism that explains the association between sexual orientation and height would be accrued. Also, such a study would help to further expand our understanding of the association between sexual orientation and height in women, which seems to be less clear relative to our understanding of the association between sexual orientation and height in men.

## 5.5 Conclusion

A number of physical correlates related to sexual orientation exist, and the additional research on physical characteristics included in the current thesis has provided new insights into research on sexual orientation. In this dissertation, three physical correlates—height, birth weight (along with fetal loss), and facial structure—were examined in order to establish the reliability of the association between these physical correlates and sexual orientation. As a result, mechanisms possibly underlying these correlates were also indirectly explored, including pubertal stressors and nutrition; a maternal immune response; and prenatal hormones. In Study 1, we found no evidence for the role of pubertal stress and pubertal nutrition in the development of sexual orientation, which provides room for other, mostly prenatal (e.g., maternal immune response, prenatal hormones), explanations of the development of sexual orientation. In Studies 2 and 3, some indirect support for prenatal mechanisms underlying the development of sexual orientation was also provided, including a maternal immune response, hormones, and developmental instability. Future research will help to provide more support for the exact mechanisms involved in the complex development of sexual orientation.

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**Appendix A.** Copyright clearance for chapter included in Section 1.2.



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**Appendix B.** Questions and response options from the Add Health data for each nutrition and stress-related variable utilized in the current study (Study 1 of the Dissertation).

| Variable | Question | Response Options |
|---|---|---|
| | Nutrition Variables | |
| Breakfast: Milk | "What do you usually have for breakfast on a weekday morning?" "milk" | Participants either marked or did not mark each breakfast food option |
| Breakfast: Coffee, tea | "coffee or tea" | |
| Breakfast: Cereal | "cereal" | |
| Breakfast: Fruit, juice | "fruit, juice" | |
| Breakfast: Eggs | "eggs" | |
| Breakfast: Meat | "meat" | |
| Breakfast: Snack food | "snack foods" | |
| Breakfast: Breads | "bread, toast, or rolls" | |
| Breakfast: Other | "other items" | |
| Breakfast: Nothing | "nothing" | |
| Ate yesterday: Dairy | "Think about all the food you ate yesterday, including meals and snacks at home, at school, at restaurants, and anywhere else." "How often did you drink milk, or eat yogurt, or cheese yesterday?" | "didn't eat," "ate once," "ate twice or more" |
| Ate yesterday: Fruit, juice | "How often did you eat fruit or drink fruit juice yesterday?" | |
| Ate yesterday: Vegetables | "How often did you eat vegetables yesterday?" | |
| Ate yesterday: Bread, pasta | "How often did you eat bread, cereal, pretzels, rice, or pasta yesterday?" | |
| Ate yesterday: Pastries | "How often did you eat cookies, doughnuts, pie, or cake yesterday?" | |
| | Exploratory Stress-Related Variables | |
| Self-rated health | "In general, how is your health? Would you say…" | "excellent," "very good," "good," "fair," "poor" |
| Health stress | "Please tell me how often you have had each of the following conditions in the past 12 months." "a headache," "feeling hot all over suddenly, for no reason," "a stomach ache | "never," "just a few times," "about once a week," "almost every |

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| | or an upset stomach," "cold sweats," "feeling physically weak, for no reason," "a sore throat or a cough," "feeling very tired, for no reason," "painful or very frequent urination (or peeing)," "feeling really sick," "waking up feeling tired," "skin problems, such as itching or pimples," "dizziness," "chest pains," "aches, pains, or soreness in your muscles or joints," "poor appetite," "trouble falling asleep or staying asleep," "trouble relaxing," "moodiness," "frequent crying," "fearfulness," "cramps during your menstrual period" (for girls) | day," "every day" |
| Parental control | "Do your parents let you make your own decisions about the time you must be home on weekend nights?," "Do your parents let you make your own decisions about the people you hang around with?," "Do your parents let you make your own decisions about what you wear?," "Do your parents let you make your own decisions about how much television you watch?," "Do your parents let you make your own decisions about which television programs you watch?," "Do your parents let you make your own decisions about what time you go to bed on week nights?," "Do your parents let you make your own decisions about what you eat?" | "no," "yes" |
| Disabled mother | "Is she disabled—that is, mentally or physically handicapped?" | "no," "yes" |
| Disabled father | "Is he disabled—that is, mentally or physically handicapped?" | "no," "yes" |
| Physical disability of participant | "Do you have difficulty using your hands, arms, legs, or feet because of a permanent physical condition?," "Do you use a cane, crutches, walker, medically prescribed shoes, wheelchair, or scooter to get around because of a permanent physical condition?," "Do you use a brace for your hand, arm, leg, or foot because of a permanent physical condition?," "Do you use an artificial hand, arm, leg, or foot?" | "no," "yes" |
| Sexual abuse | "How often did a parent or other adult caregiver touch you in a sexual way, force you to touch him or her in a sexual way, or force you to have sexual relations?" | "one time," "two times," "three to five times," "six to ten times," "more than ten times," "this has never happened" |

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| Theoretically Relevant Stress-Related Variables | | |
| Depressive symptoms | "These questions will ask about how you feel emotionally and about how you feel in general. How often was each of the following things true during the past week?"<br>"You were bothered by things that usually don't bother you," "You didn't feel like eating, your appetite was poor," "You felt that you could not shake off the blues, even with help from your family and your friends," "You felt that you were just as good as other people," "You had trouble keeping your mind on what you were doing," "You felt depressed," "You felt that you were too tired to do things," "You felt hopeful about the future," "You thought your life had been a failure," "You felt fearful," "You were happy," "You talked less than usual," "You felt lonely," "People were unfriendly to you," "You enjoyed life," "You felt sad," "You felt that people disliked you," "It was hard to get started doing things," "You felt life was not worth living" | "never or rarely," "sometimes," "a lot of the time," "most of the time or all of the time" |
| Social Network (SN): In degree, Reach, Out degree, Bonacich centrality | "List your closest male friends. List your best male friend first, then your next best friend, and so on. Girls may include boys who are friends and boyfriends."<br>"List your closest female friends. List your best female friend first, then your next best friend, and so on. Boys may include girls who are friends and girlfriends." | |
| Perceived social support | "How much do you feel that adults care about you?," "How much do you feel that your teachers care about you?," "How much do you feel that your parents care about you?," "How much do you feel that your friends care about you?," "How much do you feel that people in your family understand you?," "How much do you feel that you and your family have fun together?," "How much do you feel that your family pays attention to you?" | "not at all," "very little," "somewhat," "quite a bit," "very much" |
| Violent victimization | "During the past 12 months, how often did each of the following things happen?" "Someone pulled a knife or gun on you," "Someone shot you," "Someone cut or stabbed you," "You were jumped" | "never," "once," "more than once" |
| School belonging | "You feel close to people at your school," "You feel like you are a part of your school," "Students at your school are prejudiced," "You are | "strongly agree," "agree," "neither agree nor disagree," |

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|---|---|---|
| | happy to be at your school," "The teachers at your school treat students fairly," "You feel safe in your school" | "disagree," "strongly disagree" |
| School stress | "Since school started this year, how often have you had trouble:" "getting along with your teachers," "getting along with other students," "paying attention in school," "getting your homework done" | "never," "just a few times," "about once a week," "almost everyday," "everyday" |
| Self-esteem | "You have a lot of good qualities," "You have a lot to be proud of," "You like yourself just the way you are," "You feel like you are doing everything just about right," "You feel socially accepted," "You feel loved and wanted" | "strongly agree," "agree," "neither agree nor disagree," "disagree," "strongly disagree" |
| Parental rejection | "How often would it be true for you to make each of the following statements about the participant?" "You get along well with him/her," "He/she and you make decisions about his/her life together," "You just do not understand him/her," "You feel you can really trust him/her," "He/She interferes with your activities" | "always," "often," "sometimes," "seldom," "never" |
| Suicidal thoughts | "During the past 12 months, did you ever seriously think about committing suicide?" | "no," "yes" |
| Want to run away | "How much do you feel that you want to leave home?" | "not at all," "very little," "somewhat," "quite a bit," "very much" |
| Ever ran away | "How often did you run away from home?" | "never," "1 or 2 times," "3 or 4 times," "5 or more times" |
| Child-mother connectedness | "Most of the time, your mother is warm and loving toward you," "Your mother encourages you to be independent," "When you do something wrong that is important, your mother talks about it with you and helps you understand why it is wrong," "You are satisfied with the way your mother and you communicate with each other," "Overall, you are satisfied with your relationship with your mother," "How close do you feel to your mother?," "How much do you think she cares about you?" | For the first five items: "strongly agree," "agree," "neither agree nor disagree," "disagree," "strongly disagree" For the last two items: "not at all," "very little," "somewhat," "quite a bit," or "very much" |
| Child-father connectedness | "Most of the time, your father is warm and loving toward you," "You are satisfied with the way your father and you communicate with each | For the first three items: "strongly agree," "agree," |

| | | |
|---|---|---|
| | other," "Overall, you are satisfied with your relationship with your father," "How close do you feel to your father?," "How much do you think he cares about you?" | "neither agree nor disagree," "disagree," "strongly disagree" For the last two items: "not at all," "very little," "somewhat," "quite a bit," or "very much" |
| Physical abuse | "Before your 18th birthday, how often did a parent or adult caregiver hit you with a fist, kick you, or throw you down on the floor, into a wall, or down stairs?" | "one time," "two times," "three to five times," "six to ten times," "more than ten times," "this has never happened" |

**Appendix C**. Ethics clearance for secondary data analysis for Study 1.

Brock University
Research Ethics Office
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Bioscience Research Ethics Board

Certificate of Ethics Clearance for Human Participant Research

| | | | |
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| PRINCIPAL INVESTIGATOR: | BOGAERT, Anthony - Community Health Sciences | | |
| FILE: | 13-150 - BOGAERT | | |
| TYPE: | Ph. D. | STUDENT:<br>SUPERVISOR: | Malvina Skorska<br>Anthony Bogaert |

TITLE: Fraternal Birth Order, Height, and Sexual Orientation in Add Health

**ETHICS CLEARANCE GRANTED**

Type of Clearance: NEW Expiry Date: 12/31/2014

The Brock University Bioscience Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement. Clearance granted from 12/12/2013 to 12/31/2014.

The Tri-Council Policy Statement requires that ongoing research be monitored by, at a minimum, an annual report. Should your project extend beyond the expiry date, you are required to submit a Renewal form before 12/31/2014. Continued clearance is contingent on timely submission of reports.

To comply with the Tri-Council Policy Statement, you must also submit a final report upon completion of your project. All report forms can be found on the Research Ethics web page at http://www.brocku.ca/research/policies-and-forms/research-forms.

In addition, throughout your research, you must report promptly to the REB:

a) Changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) All adverse and/or unanticipated experiences or events that may have real or potential unfavourable implications for participants;
c) New information that may adversely affect the safety of the participants or the conduct of the study;
d) Any changes in your source of funding or new funding to a previously unfunded project.

We wish you success with your research.

Approved: [signature]

Brian Roy, Chair
Bioscience Research Ethics Board

**Note:** Brock University is accountable for the research carried out in its own jurisdiction or under its auspices and may refuse certain research even though the REB has found it ethically acceptable.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of research at that site.

**Appendix D**. Descriptive statistics for measures in Study 1 within lesbian women and heterosexual women.

Table D.1. Means, standard errors, standard deviations, and 95% confidence intervals for continuous variables by sexual orientation, within women.

| Variable | *Heterosexual Women* | | | *Lesbian Women* | | |
|---|---|---|---|---|---|---|
| | *M (SE)* | *SD*[a] | *95% CI* | *M (SE)* | *SD*[a] | *95% CI* |
| Exploratory Stress-Related Variables | | | | | | |
| Self-rated health | 2.17 (0.02) | 0.92 | 2.13–2.22 | 2.33 (0.14) | 1.03 | 2.04–2.61 |
| Health stress | 0.86 (0.01) | 0.42 | 0.84–0.87 | 0.96 (0.08) | 0.52 | 0.81–1.12 |
| Parental control | 0.27 (0.01) | 0.22 | 0.25–0.28 | 0.34 (0.04) | 0.22 | 0.26–0.42 |
| Theoretically Relevant Stress-Related Variables | | | | | | |
| Depressive symptoms | 0.61 (0.01) | 0.42 | 0.59–0.63 | 0.80 (0.08) | 0.49 | 0.64–0.96 |
| SN: In degree | 4.92 (0.15) | 3.58 | 4.61–5.22 | 3.88 (0.48) | 2.92 | 2.92–4.84 |
| SN: Reach | 64.58 (3.00) | 46.33 | 58.64–70.52 | 67.90 (11.10) | 53.01 | 45.90–89.91 |
| SN: Out degree | 4.93 (0.11) | 2.87 | 4.71–5.15 | 4.28 (0.54) | 3.04 | 3.21–5.36 |
| SN: Bonacich centrality | 0.87 (0.01) | 0.62 | 0.84–0.90 | 0.72 (0.09) | 0.61 | 0.53–0.91 |
| Perceived social support | 1.92 (0.01) | 0.58 | 1.90–1.95 | 2.14 (0.09) | 0.70 | 1.95–2.32 |
| School belonging | 2.43 (0.02) | 0.70 | 2.39–2.48 | 2.60 (0.11) | 0.72 | 2.38–2.81 |
| School stress | 0.92 (0.02) | 0.68 | 0.89–0.95 | 1.39 (0.12) | 0.80 | 1.16–1.62 |
| Self-esteem | 1.95 (0.01) | 0.61 | 1.92–1.98 | 2.12 (0.10) | 0.74 | 1.93–2.31 |
| Parent rejection | 1.89 (0.01) | 0.56 | 1.87–1.91 | 1.90 (0.09) | 0.57 | 1.73–2.07 |
| Want to run away | 2.18 (0.04) | 1.27 | 2.10–2.25 | 2.60 (0.22) | 1.43 | 2.16–3.04 |
| Child-mother connectedness | 1.68 (0.01) | 0.66 | 1.66–1.71 | 1.75 (0.10) | 0.69 | 1.54–1.96 |
| Child-father connectedness | 1.79 (0.02) | 0.81 | 1.75–1.83 | 1.97 (0.16) | 0.95 | 1.65–2.29 |
| Control Variables | | | | | | |
| Age | 28.34 (0.12) | 1.78 | 28.10–28.58 | 28.47 (0.31) | 1.88 | 27.86–29.07 |

*Note*. SN = social network.

[a] The sample standard deviation was calculated for the sample of $n$ = 14,786 participants who have a Wave IV sample weight, but without taking into account the sampling design of the data. Thus the sample standard deviation cannot be generalized to the population.

Table D.2. Frequencies and percent for dichotomous variables by sexual orientation, within women.

| Variable | *Heterosexual Women* | | | *Lesbian Women* | | |
|---|---|---|---|---|---|---|
| | *n* no[a] | *n* yes[b] | Weighted % yes[c] | *n* no[a] | *n* yes[b] | Weighted % yes[c] |
| Nutrition Variables | | | | | | |
| Breakfast: Milk | 3139 | 3125 | 51.2 | 39 | 36 | 48.4 |
| Breakfast: Coffee, tea | 5918 | 346 | 5.3 | 71 | 4 | 9.4 |
| Breakfast: Cereal | 3444 | 2820 | 46.4 | 44 | 31 | 37.0 |
| Breakfast: Fruit, juice | 4156 | 2108 | 32.8 | 56 | 19 | 23.4 |
| Breakfast: Eggs | 5434 | 830 | 12.5 | 66 | 9 | 10.8 |
| Breakfast: Meat | 5665 | 599 | 8.7 | 67 | 8 | 12.0 |
| Breakfast: Snack food | 5825 | 439 | 6.9 | 68 | 7 | 12.1 |
| Breakfast: Breads | 4089 | 2175 | 34.4 | 54 | 21 | 26.4 |
| Breakfast: Other | 5536 | 728 | 11.2 | 64 | 11 | 17.5 |
| Breakfast: Nothing | 4781 | 1483 | 23.4 | 52 | 23 | 29.6 |
| Ate yesterday: Dairy | 1315 | 4947 | 80.8 | 17 | 58 | 83.7 |
| Ate yesterday: Fruit, juice | 1329 | 4934 | 78.3 | 23 | 52 | 59.7 |
| Ate yesterday: Vegetables | 2130 | 4130 | 67.5 | 34 | 41 | 54.0 |
| Ate yesterday: Bread, pasta | 567 | 5697 | 91.6 | 12 | 63 | 82.0 |
| Ate yesterday: Pastries | 3040 | 3224 | 51.9 | 36 | 39 | 44.7 |
| Exploratory Stress-Related Variables | | | | | | |
| Disabled mother | 5636 | 290 | 5.0 | 68 | 4 | 3.4 |
| Disabled father | 4053 | 280 | 6.4 | 42 | 3 | 8.4 |
| Physical disability of participant | 5988 | 274 | 4.2 | 70 | 5 | 3.3 |
| Sexual abuse | 5836 | 395 | 6.3 | 67 | 7 | 9.9 |
| Theoretically Relevant Stress-Related Variables | | | | | | |
| Violent victimization | 5568 | 671 | 10.4 | 65 | 10 | 12.5 |
| Suicidal thoughts | 5317 | 908 | 14.5 | 62 | 13 | 15.2 |
| Ever ran away | 5701 | 536 | 8.3 | 72 | 3 | 3.2 |
| Physical abuse | 5239 | 986 | 16.0 | 55 | 17 | 18.8 |
| Control Variables | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Ethnicity | 3679 | 2576 | 30.0 | 37 | 38 | 33.6 |
| Education | 4469 | 1798 | 30.3 | 46 | 29 | 37.7 |

*Note*.

[a] This column shows the number of participants who responded "no" to a dichotomous variable. For ethnicity, it is the number of participants who were categorized as having a White ethnicity; for education, it is the number who were categorized as having a university education.

[b] This column shows the number of participants who responded "yes" to a dichotomous variable. For ethnicity, it is the number of participants who were categorized as having a non-White ethnicity; for education, it is the number who were categorized as having a non-university education.

[c] This column shows the % of yes respondents after calculation of the population estimates for the no and yes responses for dichotomous variables. Thus, the weighted % yes will not always reflect the unweighted counts in *n* no and *n* yes.

**Appendix E.** Questions mothers were asked to answer regarding each pregnancy they experienced in Study 2.

**Pregnancy number X**
Your age at end of this pregnancy: _____
Father identifier (i.e., father of the fetus; first name, nickname, initials, number, etc.): ____________________
Medical problems during pregnancy—circle the answer: **Yes** **No**. If yes, please describe below.

Medical problems during delivery—circle the answer: **Yes** **No**. If yes, please describe below.

Any method of assisted reproduction (e.g., in vitro fertilization)—circle the answer: **Yes** **No**. If yes, please describe below.

If this pregnancy resulted in one or more live births, does the child/children have (or had) any medical/health issues—circle the answer: **Yes** **No**. If yes, please describe below:

Length of pregnancy (in weeks)_____
If a baby was delivered, method of delivery—circle the answer: **C-section** **Natural**.
Number of fetuses (babies carried) in this pregnancy: ____

**Here is a table that asks about the outcome(s) of this pregnancy. Note that although most pregnancies contain one fetus, we are listing up to four fetuses in the event of that you carried more than one (e.g., twins) in this pregnancy.**

| Fetus/baby number | Fetus identifier (first name, nickname, initials, number, etc.) | Outcome—miscarriage or abortion (MA), stillbirth (S), or live birth (L) | Sex of fetus—male (M), female (F), or unknown (U) | Writing hand—right (R), left (L), both (B), or unknown (U) | Weight at birth in grams or pounds or unknown (U) | Sexual orientation[a]—heterosexual (H), gay (G), lesbian (L), bisexual (B), transsexual (T), or unknown (U) |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |

Did you intentionally try to have any more children after this pregnancy was finished?
___Yes ___No

[a]Note that mothers of natal male children clinically referred for gender dysphoria were not asked to answer this question regarding the sexual orientation of each fetus.

**Appendix F**. Ethics clearance for Study 2.

Brock

Brock University
Research Ethics Office
Tel: 905-688-5550 ext. 3035
Email: reb@brocku.ca

Bioscience Research Ethics Board

## Certificate of Ethics Clearance for Human Participant Research

DATE: 9/14/2011

PRINCIPAL INVESTIGATOR: BOGAERT, Anthony - Community Health Sciences

FILE: 10-282 - BOGAERT

TYPE: Faculty Research STUDENT:
SUPERVISOR: Anthony Bogaert

TITLE: Sexuality Orientation, Reproductive History and the Immune System

**ETHICS CLEARANCE GRANTED**

Type of Clearance: NEW Expiry Date: 9/28/2012

The Brock University Bioscience Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement. Clearance granted from 9/14/2011 to 9/28/2012.

The Tri-Council Policy Statement requires that ongoing research be monitored by, at a minimum, an annual report. Should your project extend beyond the expiry date, you are required to submit a Renewal form before 9/28/2012. Continued clearance is contingent on timely submission of reports.

To comply with the Tri-Council Policy Statement, you must also submit a final report upon completion of your project. All report forms can be found on the Research Ethics web page at http://www.brocku.ca/research/policies-and-forms/research-forms.

In addition, throughout your research, you must report promptly to the REB:

a) Changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) All adverse and/or unanticipated experiences or events that may have real or potential unfavourable implications for participants;
c) New information that may adversely affect the safety of the participants or the conduct of the study;
d) Any changes in your source of funding or new funding to a previously unfunded project.

We wish you success with your research.

Approved: [signature]

Brian Roy, Chair
Bioscience Research Ethics Board

Note: Brock University is accountable for the research carried out in its own jurisdiction or under its auspices and may refuse certain research even though the REB has found it ethically acceptable.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of research at that site.

**Appendix G**. Ethics clearance for Study 3.

Brock University
Research Ethics Board
Tel: 905-688-5550 ext. 3035
Email: reb@brocku.ca

## Certificate of Ethics Clearance for Human Participant Research

| | | |
|---|---|---|
| DATE: | January 21, 2011 | |
| PRINCIPAL INVESTIGATOR: | BOGAERT, Anthony - Community Health Sciences | |
| FILE: | 10-005 - BOGAERT | |
| TYPE: | Faculty Research | STUDENT:<br>SUPERVISOR: |

TITLE: Sexuality and Physical Development Study

**ETHICS CLEARANCE GRANTED**

Type of Clearance: MODIFICATION Expiry Date: 8/19/2011

The Brock University Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement. Clearance granted from **1/21/2011** to **8/19/2011**.

The Tri-Council Policy Statement requires that ongoing research be monitored by, at a minimum, an annual report. Should your project extend beyond the expiry date, you are required to submit a Renewal form before **8/19/2011**. Continued clearance is contingent on timely submission of reports.

To comply with the Tri-Council Policy Statement, you must also submit a final report upon completion of your project. All report forms can be found on the Research Ethics web page.

In addition, throughout your research, you must report promptly to the REB:

a) Changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) All adverse and/or unanticipated experiences or events that may have real or potential unfavourable implications for participants;
c) New information that may adversely affect the safety of the participants or the conduct of the study;
d) Any changes in your source of funding or new funding to a previously unfunded project.

We wish you success with your research.

Approved: Michelle K. McG

Michelle McGinn, Chair
Research Ethics Board (REB)

Note: Brock University is accountable for the research carried out in its own jurisdiction or under its auspices and may refuse certain research even though the REB has found it ethically acceptable.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of research at that site.