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Birth order and physical fitness in early adulthood: Evidence from Swedish military conscription data

Kieron Barclay [a, *], Mikko Myrskylä [b, c, d]

[a] Department of Sociology, Stockholm University, 106 91 Stockholm, Sweden
[b] Department of Social Policy, 2nd Floor, Old Building, London School of Economics and Political Science, Houghton Street, London WC2A 2AE, UK
[c] Max Planck Institute for Demographic Research, Konrad Zuse Str. 1, 18057 Rostock, Germany
[d] Population Research Unit, Department of Social Research, University of Helsinki, P.O. Box 18, 00014, Finland

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ABSTRACT

Physical fitness at young adult ages is an important determinant of physical health, cognitive ability, and mortality. However, few studies have addressed the relationship between early life conditions and physical fitness in adulthood. An important potential factor influencing physical fitness is birth order, which prior studies associate with several early- and later-life outcomes such as height and mortality. This is the first study to analyse the association between birth order and physical fitness in late adolescence. We use military conscription data on 218,873 Swedish males born between 1965 and 1977. Physical fitness is measured by a test of maximal working capacity, a measure of cardiovascular fitness closely related to V02max. We use linear regression with sibling fixed effects, meaning a within-family comparison, to eliminate the confounding influence of unobserved factors that vary between siblings. To understand the mechanism we further analyse whether the association between birth order and physical fitness varies by sibship size, parental socioeconomic status, birth cohort or length of the birth interval. We find a strong, negative and monotonic relationship between birth order and physical fitness. For example, third-born children have a maximal working capacity approximately 0.1 ($p < 0.000$) standard deviations lower than first-born children. The association exists both in small (3 or less children) and large families (4 or more children), in high and low socioeconomic status families, and amongst cohorts born in the 1960s and the 1970s. While in the whole population the birth order effect does not depend on the length of the birth intervals, in two-child families a longer birth interval strengthens the advantage of the first-born. Our results illustrate the importance of birth order for physical fitness, and suggest that the first-born advantage already arises in late adolescence.

1. Introduction

Physical fitness is an important dimension of physical health, consisting of a number of health-related components, including cardio-respiratory endurance, muscular endurance, muscular strength, body composition, and flexibility (Caspersen et al., 1985). Higher levels of physical fitness have been shown to be associated with higher self-rated health (Shirom et al., 2008), as well as a lower risk of suffering from all-cause and cardiovascular-related mortality at all ages, even amongst otherwise healthy individuals (Blair et al., 1995). It is known that exercise, alcohol consumption, and smoking are important predictors of physical fitness (Marti et al., 1988). Relatively little, however, is known about the relationship between physical fitness and early-life conditions. Previous studies have shown that early life adversity has negative consequences for cognitive development, educational attainment, and health in adulthood (Conley and Bennett, 2000). More particularly, studies have also shown that adverse conditions early in life can impact cardiovascular health (Alastalo et al., 2009), which would impede the ability of individuals to develop physical fitness.

An important but thus far unanalysed potential factor influencing physical fitness is birth order. Several factors indicate that being a later born child means occupying a disadvantaged position within the household. Previous research indicates that parents spend less time caring for later born children (Price, 2008), and in Sweden there is a negative relationship between birth order and time spent on parental leave (Sundström and Duvander, 2002). Recent research also shows that mothers are less likely to seek pre-

* Corresponding author.
E-mail addresses: kieron.barclay@sociology.su.se (K. Barclay), m.myrskyla@lse.ac.uk (M. Myrskylä).

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natal care for later pregnancies, and are also less likely to breast feed later born children (Buckles and Kolka, 2014). There is a long tradition of studying the relationship between birth order and outcomes ranging from personality to educational attainment and intelligence (Ernst and Angst, 1983; Black et al., 2005; Bjerkedal et al., 2007). However, relatively few studies have addressed the relationship between birth order and adult health. Studies on the relationship between birth order and suicide show that later borns have a higher risk of suicide (Bjørngaard et al., 2013; Rostila et al., 2014). All-cause mortality has also been reported to increase with birth order (Modin, 2002; Barclay and Kolk, 2013), though Modin (2002) did not use a within-family comparison, and one study using fixed effects does not support that conclusion (Rostila et al., 2014). Although studies addressing the relationship between birth order and mortality are generally identifying long-term effects on adult health, as most mortality occurs at advanced ages, the effect on health in late adolescence is much less known.

Later born men in Sweden have been shown to be shorter than their older siblings (Myrskylä et al., 2013). The inverse association between birth order and height suggests that at least part of the adverse effects of birth order on later outcomes arise relatively early in life. We therefore hypothesize that birth order may have a similar association with physical fitness at young adult ages to that which has been found for the relationship between birth order and height: that is, later-born siblings will have worse physical fitness at young adult ages than their earlier-born siblings. This study will investigate the relationship between birth order and physical fitness in late adolescence by using unprecedentedly large and high quality Swedish military conscription data on 218,873 Swedish males born between 1965 and 1977. We measure physical fitness using a stationary bicycle test to identify maximal working capacity (MWC), a measure of cardio-respiratory fitness closely related to other measures of maximal aerobic capacity, including V02max (Patton et al., 1982). Measures of cardio-respiratory fitness reflect the ability of the heart and lungs to provide oxygen to working muscles, which in turn reflects the interaction of multiple parameters, including heart rate, cardiac output, and maximal oxygen consumption.

Our study has two unique contributions both to the birth order literature and to the literature on physical fitness. First, this is the first study to analyse the association between birth order and physical fitness in late adolescence. Lower physical fitness at young adult ages is associated with continued poor health into the future, as attitudes and habits become ingrained over time (Biddle et al., 2010). Furthermore, lower physical fitness is associated with increased mortality risk even in early adulthood (Blair et al., 1995; Myers et al., 2002). Understanding the potential impact of birth order on physical fitness is important both in terms of shedding new light on the mechanisms through which birth order influences later life outcomes, and in terms of understanding where in the life course the potentially adverse effects of being of high birth order emerge. Second, while prior work has studied the relationship between birth order and cardiovascular system related mortality (Barclay and Kolk, 2013; Rostila et al., 2014), no prior work has considered birth order as a potentially important determinant of cardiovascular fitness.

2. Potential mechanisms linking birth order to later-life outcomes

Prior research has proposed both physiological and social explanations for the finding that adult outcomes are patterned by birth order. One physiological theory that has been offered for why later born children have worse outcomes is depletion of maternal nutritional reserves during pregnancy, which is particularly relevant when the birth interval is short (Gunawardana et al., 2011). However, recent research using data on families where an infant has died (Kristensen and Bjerkedal, 2007), and fully adopted sibling groups (Barclay, 2014), suggest that it is social order within the family rather than biological birth order that matters. The results by Myrskylä et al. (2013) also suggest that the birth order effect may be attributable to post-natal factors, as the inverse association between adult height and birth order was robust to controls for birth weight and length.

Research on military conscripts in Switzerland shows that both alcohol consumption and cigarette smoking have a detrimental effect on cardiovascular fitness even in early adulthood (Marti et al., 1988). Empirical research has also shown that later born siblings are more likely to begin developmentally inappropriate activities, such as a drinking and smoking, at a younger age than older siblings (Blane and Barry, 1973; Harakeha et al., 2007). This is likely to be due to both a combination of decreasing parental control as the size of sibling group increases, as well social learning based on the behaviour of older siblings, who may also facilitate access to alcohol or cigarettes for their younger siblings (Bard and Rodgers, 2003). The initiation of smoking, in particular, at a younger age is associated with a higher probability of continued addiction over the life course (Chen and Millar, 1998; Khuder et al., 1999). Given that previous research has shown that health behaviours such as cigarette and alcohol consumption are key predictors of physical fitness (Marti et al., 1988), these behaviours could be important mediators for the relationship between birth order and physical fitness in early adulthood.

An alternative theory that may be important for understanding the relationship between birth order and physical health in late adolescence is the hygiene hypothesis (Strachan, 1989). The hygiene hypothesis describes how atopic diseases, meaning hyperallergenic diseases such as hay fever, are less common in larger families (Strachan, 1989). Research suggests that infection early in life is protective against the development of atopic diseases (Strachan, 2000). Households with more children are likely to have higher rates of infections, largely due to sibling interaction. In application to birth order, the theory suggests that earlier born children may grow up in a cleaner environment, and therefore be more likely to develop atopic diseases, than later born children (Butland et al., 1997). If birth order is associated with the development of diseases that affect the respiratory system, such as hay fever, it would not be surprising to find that higher birth order children perform better on this test of physical fitness than their earlier born siblings. It should be noted, however, that a relationship between birth order and another atopic disease, allergic asthma, has not been consistently documented (Strachan, 2000). This interpretation of the hygiene hypothesis predicts a positive relationship between birth order and physical health. The potential importance of the hygiene hypothesis is, however, complicated by an alternative interpretation of the theory that predicts that later born children should in fact do worse than earlier borns. This interpretation is based upon the assumption that children bring communicable diseases into the household, and as the number of children increases, this increases the disease load within the household. Later born children may be more susceptible to these diseases, as they are younger and more frail, and this might be associated with lower physical fitness in late adolescence.

Another theory that can applied to understand the relationship between birth order and physical fitness is the resource dilution hypothesis (Blake, 1981). The resource dilution hypothesis describes how early born children are cumulatively advantaged over their later born siblings because they have exclusive, or greater, access to parental resources. Although later born children may have greater access to parental resources later in life as their older siblings leave