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Economic Transition, Male Competition, and Sex Differences in Mortality Rates

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Abstract: Sex differences in mortality rates stem from a complex set of genetic, physiological, psychological, and social causes whose interconnections are best understood in an integrative evolutionary framework. We predicted that the transition from centrally planned to market economies in Eastern Europe inflated the discrepancy between male and female mortality rates, because economic uncertainty and increasing variation and skew in social status and resources should increase risky male behavior and the impact of stress on physiological susceptibility to internal causes of death. We computed the ratio of the male mortality rate to the female mortality rate separately for 14 Eastern European countries and for the combined population of 12 Western European countries in the pre-transition (1985-1989), transition (1990-1994), and post-transition (1995-1999) periods. We found that the Male to Female Mortality Ratio (M:F MR) for 14 Eastern European nations increased during the years of economic transition, most prominently during early adulthood. Larger sex differences in mortality rates occurred in both young adulthood, reflecting a shift towards riskier behavioral strategies, and middle adulthood, indicating greater physiological susceptibility to stress. For 12 of the 14 Eastern European nations, the increase was substantially larger than the slight increase in the overall Western European M:F MR. The impact of the transition on the magnitude of mortality discrepancy across countries varies considerably and likely reflects conditions particular to each country. These findings illustrate how traits shaped by natural selection interact with environmental conditions to influence male psychology and ultimately mortality patterns.

Keywords: sex differences, evolution, mortality, Eastern Europe, economy, risk taking.

Introduction

Recognition of substantial differences between male and female mortality rates dates back to at least 1750 (Kalben, 2000). The availability of improved data in recent decades has made it possible to identify physiological and behavioral explanations for these differences. Substantial evidence now shows that men are both physiologically more vulnerable to most diseases and psychologically more prone to take risks and engage in unhealthy behavior that turns these vulnerabilities into early mortality (Folstad and Karter, 1992; Hazzard, 1986, 1990; Kraemer, 2000; Lawlor, Ebrahim, and Smith, 2001; Moore, 2002; Zhang, Sasaki, and Kesteloot, 1995).

However, efforts to explain why men are physiologically more vulnerable and psychologically more prone to risk taking have only recently begun. To answer these questions requires an evolutionary perspective on why natural selection shaped differences between men and women. This recognition in no way precludes consideration of the profound influence of culture on mortality patterns. In fact, this paper illustrates how recent cultural changes in Eastern Europe interact with evolved facultative mechanisms to influence the Male-to-Female Mortality Ratio (M:F MR).

Sex differences are usually shaped by the processes of sexual selection, intersexual selection and intrasexual competition. Evolutionary biologists recognize consistent patterns that influence mortality differences between males and females. In most species, males make a smaller parental investment than females and females tend to be more discriminating in mate choice because of their greater costs of reproduction. As a result, the reproductive success of males depends largely on their ability to compete for mating opportunities, whether by winning fights with other males, competing for social status or territory, or by presenting displays preferred by females (Darwin 1871; Trivers, 1972). Males who succeed in these competitions have more offspring, and this shapes traits that foster such success, even if those traits also lead to physiological and behavioral differences that make males more prone to injury, sickness and early death. Relative to females, the optimum balance of investment for males is shifted towards reproductive effort and away from somatic effort (building up the body and maintaining health), and towards mating effort at the expense of parental effort.

Because males benefit more so from numerous mating opportunities than do females, they were selected to invest more effort in mating than females, while females allocate proportionally more effort to improve the quality of their offspring. Male reproductive success also shows more variance and skew because most females will rear some offspring to maturity, but many males may not mate at all, and a few males are likely to have many offspring, especially in species where mating patterns are polygynous. Higher degrees of polygyny in a species correspond with greater male-male competition and risky male behavior (Plavcan, 2000; Plavcan and van Schaik 1997; Plavcan, van Schaik, and Kappeler 1995), larger size and armor of males, and higher male mortality rates as compared to females (Leuttenegger and Kelley 1977). The role of sexual selection in shaping traits that increase male mortality rates is supported by the high correlation between excess male mortality and sexual size dimorphism across mammalian taxa, after controlling for the effects of phylogeny (Promislow, 1992).

Males in many species have been shaped by trade-offs that increase competitive abilities and risk-taking that increase male reproductive success even if that decreases caution and ability to repair tissues and prevent disease (Daly and Wilson 1978; Möller, Christe, and Lux 1999; Trivers 1985). In short, males in many species are selected for success in reproductive competition even at the expense of health and longevity, so females live longer on average (Hazzard, 1990). Compared to women, men tend to have greater height and weight, more upper-body strength, higher metabolic rates, higher juvenile mortality, and later sexual maturity (for a review, see Miller, 1998). Some increased risk results directly from the greater vulnerability of male structural, physiological, endocrinological, and immunological systems, especially lower resistance to infection, injury, stress and degenerative diseases (Hazzard, 1990).

The peak sex difference in mortality rates, which occurs during young adulthood and mainly from behavioral causes, can be accounted for by the shift in male allocation of effort from mating to parenting over the life course (Kruger and Nesse, 2006). Human male mating effort peaks in young adulthood, possibly in part because young men have fewer children requiring parental investment, and also because men who have not committed their current and future resources may be more attractive partners (Hill and Kaplan, 1999).

The peacock signals its mate value though the brilliant plumage of its tail (Darwin, 1871). This costly display is an honest signal of the quality of the male's genetic investment, as it demonstrates parasite and predator resistance (Zahavi, 1975). Paternal investment is much larger in humans than in other primates (Buss and Schmitt 1993; Geary and Flinn, 2001), possibly because of the high payoffs for large investments in the care and instruction of offspring compared with our primate relatives (Fisher, 1992). This degree of investment is highly influential for determining human characteristics (see Lancaster, Altmannn, Rossi, and Sherrod, 1987). Thus, displays of wealth and social status may signal human male mate value. The high investment by human males in their children may somewhat decrease the relative importance of direct male-male physical competition but will tend to increase female choosiness and its power to select for ability and willingness to invest in potential offspring (Low, 2000). Human male competition includes direct physical and status competition, as well as competition for resources that make them more attractive to females.

In recent human ancestral times, men who controlled more resources married younger women, married more women, and produced offspring earlier (Low, 1998). In current foraging societies, even ones that are relatively egalitarian, men with higher status have more mating opportunities (Chagnon, 1992; Hill and Hurtado, 1996). Cross-culturally, men are evaluated by potential partners in terms of social status and economic power (Buss, 1994; Kenrick and Simpson, 1997). Across a wide variety of societies, male social and economic status is directly related to reproductive success (Hopcroft, 2006). During recent human evolution, males who do not have substantial resources or status may have been unable to establish long-term relationships. Thus, sexual selection helps to explain some sex differences in psychology and behavioral tendencies, including the stronger male tendencies for risk-taking, competitiveness, and sensitivity to hierarchy (Cronin, 1991). These attributes are related to competition for resources, social status, and mates (Daly and Wilson, 1985), competition which is hazardous and sometimes fatal (Betzig, 1986; Kaplan and Hill, 1985). Violent male conflict is prevalent among mammalian species and is highly correlated with rates of male mortality (Daly and Wilson, 1985).

Women have also faced unique selection pressures which may have contributed to the divergence in risky strategies. Survival of offspring depends more on maternal than paternal care and defense (Campbell, 1999), so risk taking may have been more costly to women. Sex differences in behavioral responses to stress may follow ancestral challenges. Tissue-damaging “fight or flight” responses may be observed more so in males than in females. In contrast, women may be more likely to “tend-and-befriend,” helping to protect and reduce distress in oneself and one’s children (Taylor et al., 2000). These activities, which could also be described as "huddle and hide," may also help develop and sustain social networks that facilitate recovery from adverse situations.

These patterns lead to the expectation that men in most cultures should have higher mortality rates for most causes of death across the life span. They also make the more specific prediction that differences will be maximal in young adulthood when mate competition is the most vigorous (Daly and Wilson, 1985). Recent research has confirmed these predictions, along with the hypotheses that high M:F MRs in early adulthood should result mostly from direct behavioral (or external) causes of death, such as homicide, suicide, and accidents, high M:F MRs later in life should result from internal causes such as cardiovascular disease that reflect risky behaviors much earlier in life (Kruger and Nesse, 2004, 2006). Thus, external and internal forms of mortality are both influenced by risky behaviors, although there is a delayed impact for behaviorally influenced internal causes of death.

Accidents are the fourth leading cause of death for men in the USA, but the seventh for women (Anderson, 2001). The substantially higher rates of fatal and non-fatal accidents for boys has been attributed to their systematic underestimation of risk (Kraemer, 2000), and epidemiologists are starting to recognize the evolutionary significance of disproportionate male risk-taking in their recommendations for prevention programs (Nell, 2003). The tendency for males to take more risks is thought to also account for much of the sex difference in rates of violence and the use of alcohol or illicit drugs (Kraemer, 2000). Differential rates of alcohol intake explain substantial sex differences in mortality from chronic liver disease and cirrhosis (Zhang, Sasaki, and Kesteloot, 1995). Suicide rates for young men in several Western nations are now several times that of young women (McClure, 2000). Social expectations for men may amplify the tendency to take risks (Kraemer, 2000; Doyle, 2001).

Sex differences in mortality are strongly influenced by environmental changes over time. Some of the more important ones are: 1) the presumed rise in infectious disease mortality due to increasing population size, density, and mobility since the Palaeolithic (Diamond, 1997); 2) decreases in mortality from infection in the past two centuries due to improved sanitation, 3) recent declines in general mortality rates due to modern public health and technological medicine, including vaccination and antibiotics; 4) increased mortality from lifestyle factors such as high-fat diets, lack of exercise, consumption of tobacco, alcohol, and other drugs; and 5) the novel risks from modern technologies, such as automobiles and lethal weaponry. Overall, the pattern is dominated by the huge decline in mortality from infection (Lopez, 1998), thus increasing the prominence of other causes, many of which pose higher risks to men. The decline in maternal mortality has also increased the M:F MR; between 1935 and 1956 maternal mortality dropped from 582 to 40 deaths per 100,000 live births in the USA (Guyer, Freedman, Strobino, and Sondik, 2000).

Existing mechanistic explanations of sex-based mortality differences have recently been augmented by explanations of how characteristics shaped by sexual selection interact with environmental factors (including culture, for humans) to result in these discrepancies (e.g., Wilson and Daly, 1993). Socioeconomic factors have been shown to differentially affect male mortality. Both education level and income have a stronger impact on mortality rates for men than for women. (Bopp and Minder, 2003; Martikainen, Makela, Koskinen, and Valkonene, 2001). Evolutionary life history theory predicts that individuals who develop in relatively more uncertain environments will develop riskier behavioral strategies to take advantage of possibly fleeting opportunities (Chisholm 1999; Roff, 1992; Stearns, 1992). The steep discounting of the future by young people could be a rational response to uncertainty (e.g., Gardner, 1993; Wilson and Daly, 1997). A convex upward association between proximate outcomes of risk-taking (e.g., social status) and reproductive success in unpredictable environments (e.g., high skew) would cause the mean fitness benefit of risky strategies to be more favorable than that of cautious strategies, even if the majority of those exhibiting risky strategies have detrimental outcomes (Wilson and Daly 1997). This would maintain higher male tendencies for risk taking, even if it results in drastic consequences for many men.

We suggest that the degree of economic variability and uncertainly over time also impacts the sex difference in mortality rates. The area under the M:F MR curve, especially the area in early life that results largely from external causes, may prove to be a useful indicator that reflects some systematic characteristics of cultures, such as the severity of male-male competition, levels of political instability, or degree of inequality in social status and control of resources. Central and Eastern European nations undergoing the transition in the 1990s from centrally planned economies and one-party political systems to democratic market economies provide an excellent opportunity to examine this hypothesis, and high quality national level mortality data is readily available for many of these countries.

Although many in the West may have seen the fall of the “Iron Curtain” as an overwhelmingly positive event accompanied by increases in freedom and opportunity, it was traumatic economically and socially for the populations undergoing transition. The collapse of the Soviet Union led to increased inflation, unemployment, and lower wages (Little, 1998), and the life expectancy for men dropped by six years between 1991 and 1994 (Cockerham, 1997). Physical hardships, social disruption, and social distress associated with the 44% decline in Russia’s GDP is believed to have caused 3.4 million pre-mature deaths (Rosefielde, 2001). The increase in mortality rates was more pronounced for men than for women (Little, 1998). East Germany (the German Democratic Republic, GDR) had the advantage of support from West Germany (the Federal Republic of Germany, FRG), resulting in a dramatic increase in wages and a higher standard of living than all other Central and Eastern European transforming countries (Seliger, 2001c). However, despite the input of nearly three trillion Deutschmarks by 2001 as well as technical and managerial assistance, unemployment rates were twice as high in the former GDR as in the FRG throughout the 1990s (Seliger, 2001c).

Open competition with more technologically advanced and efficient western firms, as well as the purchase and elimination of eastern firms by western firms, resulted in a dramatic decline in the GDR's industrial output (Seliger, 2001b). Prior to the transition, inefficient firms with deficits were subsidized and bankruptcy was unknown (Seliger, 2001a). Wages and prices were fixed for long periods of time and did not reflect scarcities. Centralized economic plans were distorted by incorrect information and production outside the plan (Seliger, 2001a, 2001b). Firms attempted to increase per worker productivity by reducing the workforce, resulting in shortages. Seliger estimates that approximately half of the workers in the former GDR lost their jobs between 1989 and 1993 (Seliger, 2001c). Almost 600,000 people, mostly younger adults, left East Germany between October 1989 and March 1990 (Seliger, 2001b).

During the socialist period, social status and material wealth variation and skew were relatively small for most of the population, and employment, although not freely chosen, was guaranteed. The relatively lower payoffs for aggressive competition should reduce the tendency for risky male behavioral strategies and decrease the rates of male mortality from behavioral causes. During and after the rapid transition to a market economy, the variance and skew in social status and resources increased tremendously.

Gini coefficient is a measure of inequality of a distribution (Gini, 1921), it is frequently used to measure the degree of income inequality in a population. Russia had a Gini coefficient for income of .27 in the late 1980s that rose to .41 in 1993-94. The ratio of the income of the richest 10% of the population to the poorest 10% of the population went from 3.16 to 15.10 (United Nations Development Program, 1998). The rise in income inequality has coincided with large bonuses, systematic tax evasion, and substantial incomes from undeclared transactions amongst high-income earners (United Nations Development Program, 1998). The uncertainty about the future and greater degree of competition was likely to lead to riskier male behavioral strategies and higher male mortality. This is not to say that the transition was not stressful to women as well, only that the magnitude of the male to female mortality gap would widen according to predictions from our evolutionary framework.

Materials and Methods

The Male:Female Morality Ratio (M:F MR) is the ratio of the male mortality rate to the female mortality rate in a specific population. We computed M:F MRs between 1985 and 1999 for Albania, Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russian Federation, Slovenia, and the Ukraine with data from the World Health Organization (http://www3.who.int/whosis/menu.cfm) and former German Democratic Republic (GDR, East Germany) with data from the Human Mortality Database (www.mortality.org). For comparisons, we computed the overall M:F MR between 1985 and 1999 for 12 countries in Western Europe: Austria, Finland, France, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, and United Kingdom with data from the World Health Organization; the former Federal Republic of Germany (FRG, West Germany) with data from the Human Mortality Database.

Data were not available for Albania in 1985, 1990, and 1991; Czech Republic in

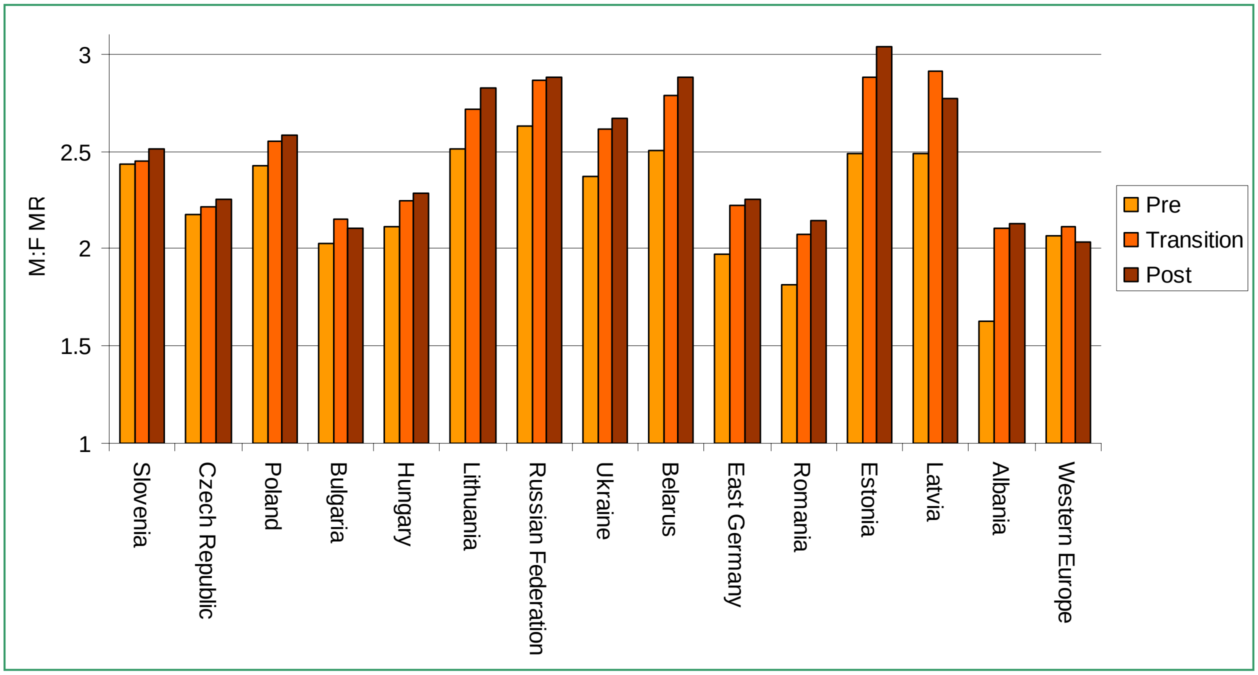
1985; and Poland in 1997 and 1998. We excluded Albanian data from 1997-1999 due to civil conflict. All other years of data were used to compute the M:F MRs by country for the pre-transition (1985-1989), transition (1990-1994), and post-transition (1995-1999) periods. We excluded data from Armenia, Azerbaijan, Croatia, and Moldova due to war and Georgia due to civil war in the period of interest.

We graphed the M:F MR for the total population of the 14 countries across the years of economic transition with age in years on the x axis. We graphed the M:F MR across age groups for the combined populations of Albania, Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russian Federation, and the Ukraine in the pre-transition (1985-1989), transition (1990-1994), and post-transition (1995-1999) periods. We repeated this process for behavioral (including accidents, homicides, and suicides) and internal causes (all other causes, e.g., cardiovascular disease, malignant neoplasms (cancer), cerebrovascular disease, pneumonia and influenza, diabetes mellitus, congenital abnormalities, liver disease and cirrhosis, hypertension, and other forms of mortality not acutely caused by behavior). We calculated the ratio of East German M:F MR to West German M:F MR between 1980 and 1999 with data from the Human Mortality Database.

Results

All 14 countries showed an increase in the M:F MR in the first five years of the economic transition (See Figure 1), however the size of the increase varied considerably across the nations. The M:F MR for Slovenia and the Czech Republic increased 1 and 2%, respectively; Poland, Bulgaria, and Hungary increased 5-6%; Lithuania, Russian Federation, and Ukraine increased 8-10%; Belarus, East Germany, and Romania increased 11-14%; Estonia and Latvia increased 16-17%; and Albania increased 30%. Changes were smaller in the transition to post-transition period: The M:F MR for Latvia declined 5%; Bulgaria declined 2%; Russian Federation, Albania, and Poland increased 1%; Czech Republic, Hungary, and Ukraine increased 2%; Belarus and Slovenia increased 3%; Romania and Lithuania increased 4%; and Estonia increased 5%. The M:F MR for the total population of these nations increased by 9.3% during the economic transition. In comparison, the overall M:F MR for 12 combined countries in Western Europe increased 2.4% in the first five years of the Eastern European economic transition and declined 4.6% in the following five years. The increase in the overall M:F MR was substantially greater for Eastern European countries than Western European countries during the economic transition, $F(1,24) = 22.12$, $p < .001$.

Figure 1. Overall M:F MR Across the Economic Transition in 14 Nations and for Western Europe (12 Nations)



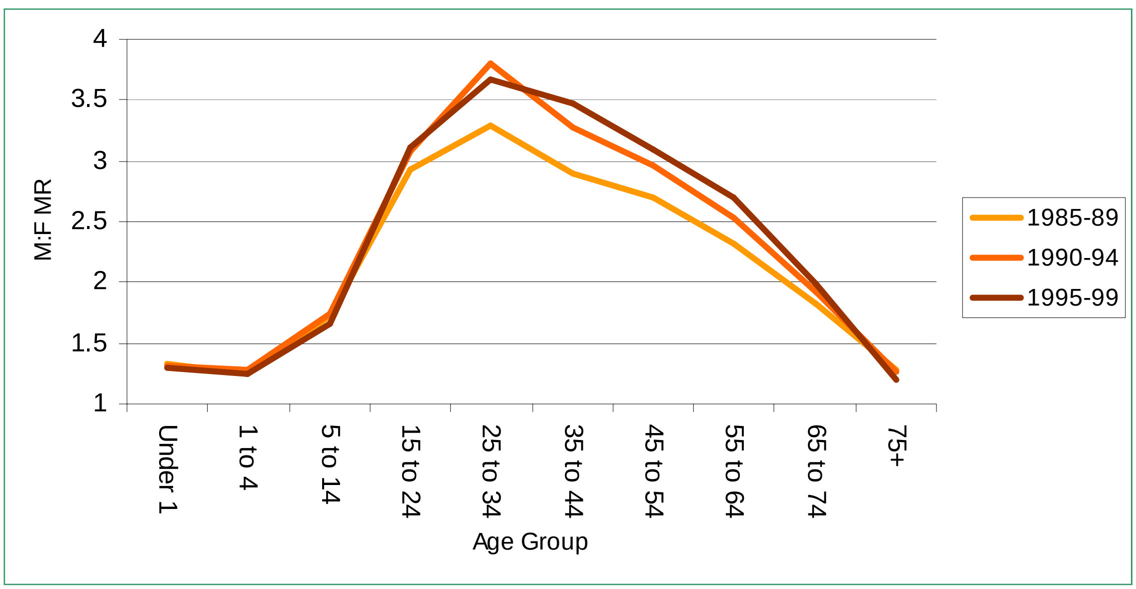
The comparison between the M:F MRs in East Germany (GDR) and West Germany (FRG) further confirmed our predictions (see Table 1). Despite higher mortality rates for both men and women in the GDR prior to unification, the M:F MR in the GDR was lower than that of the FRG in 1980-1984. The M:F MRs for GDR and FRG were nearly equivalent in 1985-1989. After unification, the M:F MR in the GDR rose considerably relative to that of the FRG. The difference in M:F MRs increased again in the period several years after unification.

Table 1. Ratio of East German M:F MR to West German M:F MR across the economic transition

Year	1980-84	1985-89	1990-94	1995-99
Ratio	0.980	1.006	1.124	1.164

Although absolute mortality rates and Male:Female ratios differ substantially in different countries, the form of the M:F MR curve for the combined population of 14 countries in economic transition (see Figure 2) are consistent with those of other nations (Kruger and Nesse, 2004). There is a dramatic increase in the M:F MR during young and middle adulthood between the pre-transition (1985-89) and transition (1990-94) periods. The M:F MR between ages 0 and 14 showed increase of less than 2%. The M:F MR for the 15 to 24 year age group increased by 5%, M:F MR for the 25 to 34 year age group demonstrated the largest increase at 15%. The magnitude of the M:F MR increase declined from 13% to 9% to 5% across the 45 to 54, 55 to 64, and 65 to 74 year age groups, respectively. The M:F MR for the 75+ year age group actually declined by 1%.

Figure 2. M:F MR Across the Lifespan During the Economic Transition for 14 Nations



The mortality ratio increased most evidently for those between 25 and 64 years of age. There was little change in age groups younger or older than this range. The M:F MR for behavioral causes across the lifespan is similar to that of all causes of mortality (see Figure 3). The major differences are that the M:F MR for the 25 to 34 year age group declined in the post-transition period more so for behavioral causes than for total mortality, and the behavioral cause M:F MR in the 55 to 74 year age range showed a larger divergence between the transition and post-transition periods, compared to total mortality. The M:F MR for internal causes shows an inverted U-shaped pattern, peaking for the 35 to 44 year age group (see Figure 4). The increase in the M:F MR for internal causes during the economic transition occurred primarily between 25 and 64 years of age. The shape of the curve in the post-transition period is quite similar, with slightly higher M:F MRs in some age groups.

Figure 3. Behavioral Cause M:F MR Across the Lifespan During the Economic Transition for 14 Nations

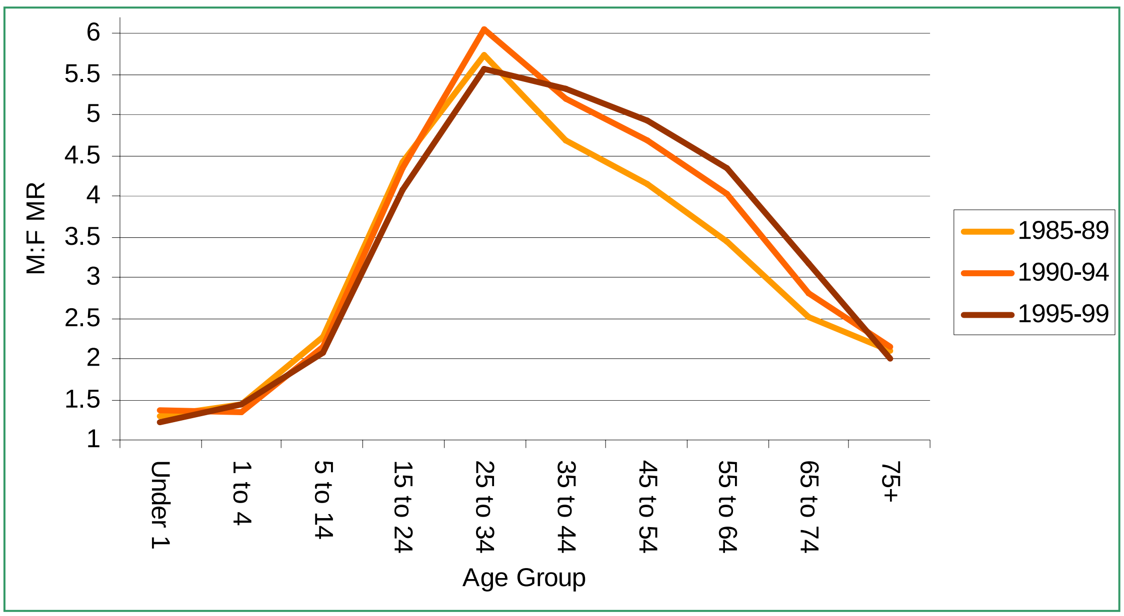
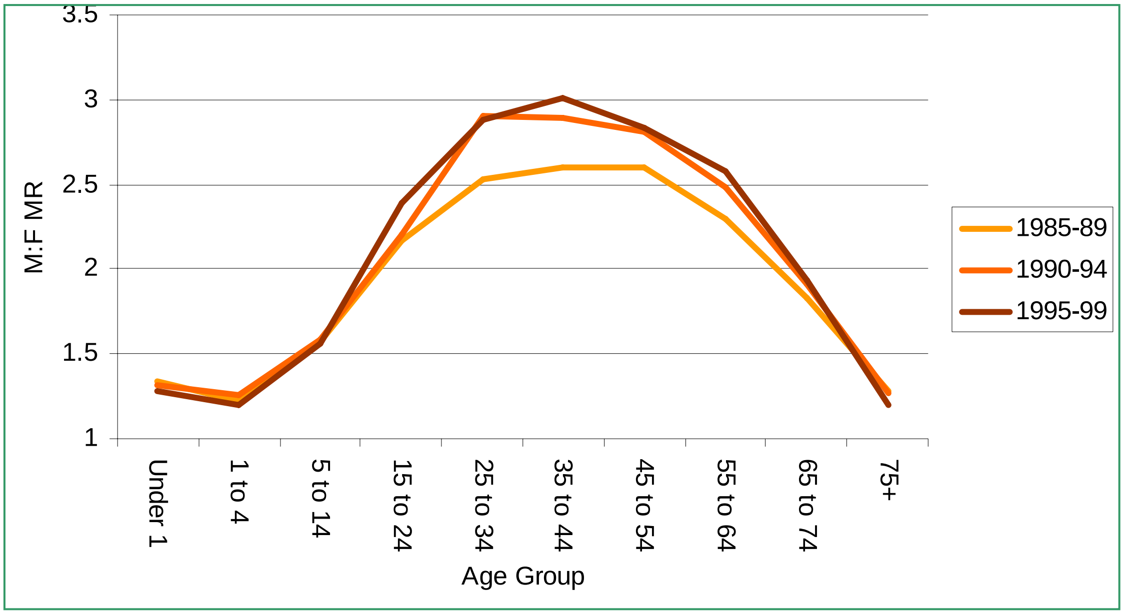


Figure 4. Internal Cause M:F MR Across the Lifespan During the Economic Transition for 14 Nations



Mortality from external causes includes both accidents and intentional injuries. For countries other than Slovenia, overall morality rates from intentional causes (homicides and other violence) increased across the economic transition. These increases ranged from 15% in Poland to 238% in Estonia; with an overall average increase of 109% across 12 countries (data were not available for Romania and East Germany). Overall morality rates from intentional causes declined by 59% in Slovenia. The M:F MR from intentional causes (homicides and other violence) increased for all Eastern European nations, with increases ranging from 12% in Poland to 123% in Albania across the economic transition, with an average increase of 39% across the 12 countries. The increases in mortality rates for intentional causes, $t(11) = 3.07$, $p = .011$, and the intentional cause M:F MR, $t(11) = 3.97$, $p = .002$, were statistically significant.

Discussion

The changes in the M:F MR during the Eastern European transition from a centrally planned socialist economy to a capitalist free market economy are consistent with predictions derived from an evolutionary understanding of how traits shaped by sexual selection interact with aspects of the current environment to influence sex differences in mortality. When the centrally planned economy was disrupted, the emerging market economy (including the novel competition with firms in Western nations) triggered higher degrees of uncertainty, instability, and inequality resulting in a shift toward riskier male strategies. This is a likely explanation for the observed increase in male mortality, relative to female mortality. The comparison with Western Europe, which does not exhibit the same increase, and between East Germany (GDR) and West Germany (FRG) further support our predictions. The dramatic increase in the M:F MR for intentional causes (e.g., homicide and other violence) further buttresses the argument for a shift towards riskier behavioral strategies.

The variation in the magnitude of M:F MR increase probably relates to the circumstances unique to each nation. The more central Eastern European nations have made more substantial progress in implementing political and economical reforms and have higher per-capita incomes than the states of the former Soviet Union (Fateyev, 2000; Sokol, 2001), which may account for the smaller M:F MR increase in the former compared to the latter. The economic transition in the Czech Republic was not marked by the high unemployment seen in other Eastern European nations; in fact, Czech unemployment was lower than the rate for major European economies and the United States (see Gitter and Scheuer, 1998). This could help explain the small M:F MR increase in the Czech Republic, compared to the other nations in transition. Slovenia may be an atypical case, as it is a former Yugoslav country which experienced a remarkably painless transition and already had many elements of a market economy.

It has been suggested that out-migration of the most educated and resourceful (and presumably the healthiest) individuals to western countries (see Anderson, 2002) was responsible for increased mortality. However, out-migration continued in the post-transition period and M:F MR levels did not exhibit the same magnitude of increase, some declined and only 3 increased more than 3%. Thus, out-migration may be responsible for some, but not all, of the mortality increase. Changing gender roles and growth of smoking and alcohol consumption rates among young women in post-transition societies are important factors that will influence mortality differences, although the impact on mortality will be delayed by at least two decades (see Lopez, 1998; Macfarlane, Macfarlane, and Lowenfels, 1996).

The mortality ratio increased most evidently in early and mid-adulthood. There was little change in the ages outside of economic productivity, either during childhood or after retirement. The increase in the mortality ratio was also lower for the 15 to 24 year age group than for other age groups in the workforce. This suggests that the economic transition had a greater impact on those who had already established careers than emerging workers. These individuals may not have seen the transition as providing new opportunities as much as younger individuals did. If we look at sex differences in mortality from behavioral causes, in addition to the increase in the mortality discrepancy, we see what looks like a cohort effect. Younger individuals appear to have less change in risky behaviors than older individuals, as the sex difference in mortality in the years after the transition was lower than that before the transition for those up to the age of 34, whereas the opposite is true for older age groups. The sex difference in mortality from internal causes of death shows a similar increase across the ages of economic productivity, similar to that for behavioral causes of death. Note that all of these age groups show an effect of physiological susceptibility to stress, although this does not occur for the 15 to 24 year age group until after the initial transition period.

The behavioral shift towards riskier strategies may correspond with evolved facultative adaptations (i.e. responsive to the environment of a particular individual's lifetime) to ancestral environmental changes. For example, from 200,000 to 10,000 years ago, climate change was quite rapid and dramatic ecological changes may have occurred within one generation (Ditlevsen, Svensmark, and Johnsen, 1996). This necessitated often risky migrations into unknown areas in search of food, shelter, or better climate (see Hoffecker, 2002; Templeton, 2002). Although migration to new areas impacted all members of a group, other changes in social and/or ecological conditions may have more specifically affected patterns of male social status and/or resource holdings.

The results of this study have several implications for understanding male psychology. Excess male mortality is a cross-cultural phenomenon and thus requires an explanation that includes more than just cultural influences. We believe that male psychology has been shaped in part by the challenges faced by our distant ancestors. These include the challenges of gathering resources, securing social status, and successfully attracting and retaining mates. The mortality discrepancy is greatest in late adolescence and young adulthood, the ages men enter the mating market. Mortality in early adulthood is predominantly due to behavioral causes; accidents, homicides, and suicides (Kruger and Nesse, 2004). This framework contrasts with traditional developmental models which see tendencies for risk-taking behaviors as a sign of psychological immaturity. Adolescents are expected to outgrow their psychosocial vulnerability to risky behaviors that may impair their health despite their underlying good biological health. Although the greatest change in the M:F MR is seen in early adulthood, the impact continues through retirement age. In middle to late adulthood, internal causes account for the majority of deaths and the difference between male and female mortality rates (Kruger and Nesse, 2004). This study demonstrates socio-economic changes affecting social status and economic potential influence both male tendencies for risky behavior and physiological susceptibility. It is notable that little or no increase in the M:F MR occurs prior to sexual maturity or after retirement.

We are not implying that men consciously think that they are adjusting their behavior because they see a threat to their reproductive success. From an evolutionary perspective, it is not necessary for the psychological mechanism to be this explicit. An inherent tendency towards an adaptive behavior will spread regardless of the subjective mental experience (or non-experience) of the individual, as long as the action reliably occurs. We also do not believe that the "fittest" male specimens are engaging disproportionately in the risky activities. These tendencies developed because they promoted reproductive success in our ancestral environment. They are not necessarily related to reproductive success in the current environment, which is quite different from the environments experienced by our ancestors. For example, our desires for sweet and fatty foods, which were previously scarce, are contributing to our modern obesity epidemic.

The results of this study suggest that the M:F MR may become a valuable quantitative psycho-social indicator that reflects the degree of male-male competition and skew of outcomes related to ancestral reproductive success in a culture. Our approach highlights interactions between adaptations developed during human evolutionary history and current social and environmental factors. This integrative approach transcends the unproductive debates over the respective roles of biology and culture in shaping human psychology.

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