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Influences of population size and density on birthplace effects

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ABSTRACT

Contextual influences on talent development (e.g., birthplace effects) have become a topic of interest for sport scientists. Birthplace effects occur when being born in a certain city size leads to participation or performance advantages, typically for those born in smaller or mid-sized cities. The purpose of this study was to investigate birthplace effects in Portuguese volleyball players by analysing city size, as well as population density – an important but infrequently used variable. Participants included 4062 volleyball players (M_{age} = 33), 53.2% of whom were men. Using Portuguese national census data from 1981, we compared participants (within each sex) across five population categories. In addition, we used ANOVAs to study expertise and population density. Results indicated that men and women athletes born in districts of 200,000–399,999 were 2.4 times more likely to attain elite volleyball status, while all other districts decreased the odds of expert development. For men, being born in high-density areas resulted in less chance of achieving expertise, whereas there were no differences for women. The results suggest that athletes' infrastructure and social structure play an important role in talent development, and that these structures are influenced by total population and population density, respectively.

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Birthplace; sport development; youth sport; volleyball

Birthplace is an important environmental variable that influences early exposure to sport and long-term expertise (Côté, Baker, & Abernethy, 2007; Côté, MacDonald, Baker, & Abernethy, 2006). Birthplace effects were originally reported in Curtis and Birch (1987) study of American and Canadian ice hockey players. The authors identified an over-representation of elite-standard ice hockey players born in cities between 100,000 and 499,999 inhabitants, suggesting that an optimal city size facilitated advancement into professional ice hockey. More recently, Côté et al. (2006) analysed the birthplace of professional American athletes in baseball, basketball, ice hockey and golf, and identified that the best odds of becoming a professional athlete were for athletes born in cities with populations between 50,000 and 100,000. Similar results have been identified when investigating birthplace effects in American football (MacDonald, Cheung, Côté, & Abernethy, 2009), women's golf (MacDonald, King, Côté, & Abernethy, 2009), various Australian national teams (Abernethy & Farrow, 2005) and Swedish tennis players (Carlson, 1988). Participation rates of Canadian youth ice hockey players have an association between smaller cities and increased ice hockey participation (Imtiaz, Hancock, Vierimaa, & Côté, 2014; Turnnidge, Hancock, & Côté, 2014). Collectively, the results of these studies indicate smaller cities facilitate sport participation and performance in large countries such as Canada, United States and Australia.

Early developmental opportunities in smaller cities are more conducive to talent development than the opportunities in larger cities (Côté et al., 2006; MacDonald et al., 2009; Turnnidge et al., 2014). The environmental structure of smaller cities in North America, for instance, might facilitate greater and more diverse sport involvement at younger ages (i.e., sampling; Côté, 1999), which in turn might lead to increased investment in sport at later stages of development (Côté et al., 2007, 2006). It has been posited that smaller cities provide an intimate and supportive environment that offers several favourable conditions for talent development, including easy access to spaces supporting unlimited and variable play/practice opportunities, early exposure to sport activities, competitions with older peers or adults and broad cross-sport experiences (Baker, Schorer, Cobley, Schimmer, & Wattie, 2009; Côté et al., 2006; Turnnidge et al., 2014). Alternatively, larger cities could be less conducive to expert development as they provide less facility access and environmental support for sport development (Côté et al., 2007, 2006).

Though most birthplace studies have shown that being born in a smaller city is advantageous for attaining sport expertise, there are exceptions across countries, cultures and sports. For instance, Baker et al. (2009) noted that optimal city sizes for producing Olympic athletes were 10,000–29,999 in United Kingdom, 250,000–499,999 in United States, 1,000,000–2,499,999 in Canada and 2,500,000–4,999,999 in Germany, suggesting that birthplace effects are buffered by broader sport-specific, sociocultural and geographical factors. In addition, Lidor, Arnon, Maayan, Gershon, and Côté's (2014) study of Israeli women ballgame players demonstrated that different sports in the same country produced mixed findings. While being born in a medium city (50,000–200,000) was advantageous for achieving expertise in basketball and handball, being born in a very small city (fewer than 2000 people) was beneficial for expert development in volleyball players. These findings support the notion that birthplace is a proxy measure to understand the developmental circumstances of athletes, but results need to be

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contextualised in the geographical situation of a country and the sport being examined (Côté et al., 2006).

Despite their importance, theoretical conceptualisations about birthplace effects are limited. To our knowledge, the sole model to explain birthplace effects was by Hancock and Côté (2014) – adapted from a relative-age-effects model (Hancock, Adler, & Côté, 2013). Hancock and Côté's (2014) model is based on social agents' (parents, coaches and athletes) impact on birthplace effects through Matthew effects (initial advantages that persist over time; Merton, 1968), Pygmalion effects (initial expectations dictate subsequent outcomes; Rosenthal & Jacobson, 1968) and Galatea effects (external expectations influence individual behaviours; Merton, 1957). The authors proposed that, compared with those in larger cities, parents in smaller cities have fewer safety concerns, leading them to encourage their children to play outside. Children in smaller cities, then, are provided initial advantages (Matthew effect) of increased free play, contributing to talent development (Côté, 1999). Similarly, in smaller cities, coaches facilitate Pygmalion effects through expectations of long-term participation, enjoyment and skill development (keys to expert development; Côté, 1999) rather than focusing on immediate performance of a selected group of children, which might align with sport structures in larger cities (Hancock & Côté, 2014). Finally, birthplace effects can be linked to Galatea effects through the big-fish-little-pond-effect (Marsh, Chessor, Craven, & Roche, 1995). Essentially, young athletes in smaller cities are more likely to have the support of the entire city, elevating athletes' self-concept and expectations for success, regardless of whether or not the athletes are more talented than those in larger cities (Balish & Côté, 2014; Hancock & Côté, 2014).

While Hancock and Côté's (2014) model provides insights into birthplace effects, it is limited (as are most previous birthplace studies) by using birthplace population as a proxy to examine the impact of a city on an athlete's early development. Focusing solely on population size provides little information about a city's internal structure – perhaps contributing to equivocal birthplace effects findings across countries. For instance, an athlete might be born in a small, but highly dense city. Illustrating this point, consider the difference between Paris and Toronto. With populations of 2,265,886 and 2,615,060, respectively, the two cities are nearly identical in total population. Paris, however, has a population density of 21,498 km^2, while Toronto's density is 4149 km^2. A growing body of literature has highlighted the strong influence of urban density on living standards and social interactions (Dempsey, Brown, & Bramley, 2012; Oakes, Forsyth, & Schmitz, 2007; Raman, 2010). Targeting density and walking behaviour, Oakes et al. (2007) reported that less-densely populated areas promoted more leisure walking activities, thereby increasing physical activity. In a similar vein, Fuller and Gaston (2009) study on European cities demonstrated that low-density cities were more likely to have green spaces, providing citizens with opportunities to experience nature and increase quality of life. Additional findings indicated that low-density cities also promoted stronger social interactions and social networks (Dempsey et al., 2012; Lawson, 2010; Raman, 2010).

This evidence suggests that population density has an important influence in determining athletes' early developmental environments, perhaps more so than population size. Despite the relevance of this evidence, studies on the influence of city density in athlete development and expert achievement are scarce. One known exception was a recent analysis of handball and soccer players (Rossing, Nielsen, Elbe, & Karbing, 2016). Therein, Rossing et al. (2016) examined community size and density among youth handball and soccer players. Overall, being born in small, low-density communities increased the likelihood of enrolling as handball or soccer players. For elite-standard players, however, being born in communities with medium densities increased the likelihood of attaining elite handball status (no differences existed for community size), but unexpectedly – and contrary to Hancock and Côté's (2014) model – soccer players' odds of achieving expertise improved when born in medium-sized, high-density communities. As established, birthplace effects vary among countries and sports, thus further examinations of population density are warranted.

Hence, the purposes of this study were to investigate birthplace effects in (1) a men's Portuguese volleyball sample and (2) a women's Portuguese volleyball sample. Through examining population size and density, we intended to improve scrutiny of such effects. In addition, we sought to examine birthplace effects within men and women athletes across three competitive standards. We aimed to improve understanding of mechanisms that underpin birthplace effects.

Methods

All procedures followed the guidelines stated in the Declaration of Helsinki and were approved by the ethics committee of the second author's institution.

Participants

Participants were elite-standard Portuguese volleyball players. Players' sex, age, birthplace and competitive standard were provided by the Portuguese Volleyball Federation through a player database spanning from 2000 to 2010. The database included 4062 volleyball players, 2159 (53.2%) of whom were men and 1903 (46.8%) were women. Participants' mean age was 33 years, with a range from 19 to 64 years. In Portugal, elite-standard men and women adult volleyball players compete in a national competition system composed of first-, second- and third-league. First-league is the highest competitive standard and third-league is the lowest competitive standard. For our sample, 33.9% were first-league players, 42.0% were second-league players and 24.1% were third-league players. From the database, two assumptions were made. First, we assumed that birthplace coincided with city of development – a standard practice in birthplace effects literature (e.g., Côté et al., 2006). However, this is not the case for all participants, so we acknowledge we could not account for possible childhood migration. Second, the database provided participants' current competitive standards. Thus, we also recognise we could not account for athletes who might have previously attained – or will attain – higher competitive standards.

Data analysis

For analysis, we used data from Portugal's 1981 census, as this was the time when most participants were children. Census data in Portugal (Census of Portugal, 1981) provide values for city/town/village sizes (henceforth termed *cities*), as well as districts/regions (henceforth termed *districts*). Herein, we focus on the district data. This was intentionally chosen because of the nature of Portuguese cities, which are often categorised as smaller than 2000 inhabitants, even though each city could have no obvious border between it and other cities. As such, small, geographically clustered cities might not be representative of a traditional small city. Instead, we used districts to improve indications of participants' birthplaces. Portugal consists of 18 districts and two autonomous regions (Madeira and Azores); as there are no discernible differences between the two categorisations that would impact this study, we chose to refer to them simply as districts. The smallest district in the sample had a population of 142,905 while the largest was 2,069,467.

Typically, birthplace effects' researchers have created city size categories for analysis. Using the manufactured categories, expected and observed proportions of participants born in each category are determined. For example, if 20% of the general population was born in cities of >1,000,000 inhabitants, then 20% of the sample would also be expected to be born in cities of >1,000,000 inhabitants. The district sizes used herein, however, did not coincide with city size categories used by previous researchers (e.g., Côté et al., 2006), though using city data would have presented the same problem. The Portuguese census data allowed separation into five district categories: category 1 (<200,000), category 2 (200,000–399,999), category 3 (400,000–599,999), category 4 (600,000–799,999) and category 5 (>799,999).

Creating district categories allowed analysis of birthplace effects in the traditional manner; i.e., total population of each district category. Odds ratios (ORs) were calculated (using Microsoft Excel 2010) to determine the probability that participants in each district category would appear in the database. For interpretation, ORs greater than 1.0 (i.e., the upper and lower confidence intervals (CIs) exceed 1.0) indicated that a district category size produced more volleyball players than expected. Conversely, ORs less than 1.0 (i.e., the upper and lower CIs less than 1.0) denoted that a district category size produced fewer volleyball players than expected. When CIs included 1.0, the ORs did not differ.

A unique component of the present study was an additional analysis of birthplace effects using population density, which might be more indicative of a district's structure and environment. Separate one-way analysis of variance (ANOVA; using SPSS 22) tests examined if population density (inhabitants per km^2) differed within each sex according to expertise (i.e., first-, second- and third-league). Separate ANOVAs were reflective of our research questions, which treated men and women as independent samples. Pearson r effect sizes (0.10 = small, 0.30 = medium, 0.50 = large; Field, 2013) and power ($1 - \beta$; provided for statistically non-significant tests) were also provided. There were no univariate outliers in the data, but because the data were skewed, the men's and women's data violated Levene's test of homogeneity ($P < 0.05$). For the men, square root and Log_{10} transformations did not reduce skewness; thus, the Brown–Forsythe correction (with Dunnett's T3 post hoc test) was used (Tabachnick, Fidell, & Osterlind, 2001). For the women's data, the Log_{10} transformation reduced the data skewness, which then did not violate Levene's test of homogeneity ($P = 0.42$). Hence, the transformed data were used for the ANOVA and Tukey's HSD post hoc test (Tabachnick et al., 2001).

Results

Starting with the traditional birthplace-effects analysis, ORs indicated identical patterns for men and women players. To avoid repetition, all participants are presented simultaneously. An over-representation of participants were born in district category 2 (200,000–399,999), OR = 2.37, CI = 2.22–2.53. Athletes born in a district with 200,000–399,999 inhabitants were nearly 2.4 times more likely to achieve elite volleyball status. Conversely, all other district sizes had under-representations of participants, i.e., being born in any other district reduced the likelihood of achieving elite-standard volleyball status (see Table 1). This result was pervasive across competitive standards.

Transitioning to population density (see Figure 1), elite-standard men volleyball players differed: $F(2, 1980.5) = 9.241$, $P < 0.001$, $r = 0.09$. Post hoc analysis revealed that first-league players came from less-densely populated districts ($M = 330.7$, $SD = 273.1$) than did third-league players ($M = 392.5$, $SD = 286.6$), but there were no other group differences. For elite-standard women athletes, there were no group differences on population density according to expertise: $F(2, 1902) = 1.559$, $P = 0.211$, $r = 0.04$, $1 - \beta = 0.332$.

Discussion

Using population size and density, the purposes of this study were to analyse birthplace effects in (1) men's Portuguese volleyball players and (2) women's Portuguese volleyball players. As we examined elite-standard men and women volleyball players, we compared results across competitive standards, but within each sex. The inclusion of different samples from the same sport and region strengthened this research. Men and women athletes were 2.4 times more likely to be represented in the database if they were born in a district of 200,000–399,999 people (the second smallest district size). All other district sizes had disproportionately fewer athletes than expected. This result is consistent with previous literature on birthplace effects in North America and Australia showing the most and least populous cities are not effective at producing elite athletes (e.g., Abernethy & Farrow, 2005; Côté et al., 2006;

Table 1. Odds ratios (OR) and confidence intervals (CI) across district categories.

City size	Population (%)	Volleyball (%)	OR	CI
>799,999	36.9	32.8	0.84	0.78–0.89
600,000–799,999	20.2	16.7	0.79	0.73–0.86
400,000–599,999	17.6	12.5	0.67	0.61–0.73
200,000–399,999	18.1	34.4	2.37	2.22–2.53
<200,000	7.1	3.6	0.49	0.42–0.58

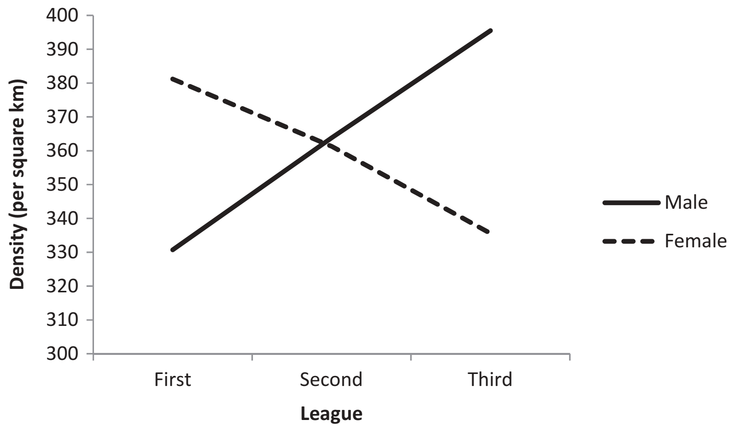

Figure 1. Population density and expertise for male and female volleyball players.

Turnnidge et al., 2014). When analysing population density, first-league men players were more likely to come from less-densely populated districts. Conversely, this was not the case for women athletes. Thus, for men athletes, the probability of attaining elite volleyball status is facilitated by being born in smaller, less-densely populated districts. Women, on the other hand, are afforded expertise advantages by being born in smaller cities, regardless of population density.

These results, combined with those from Rossing et al. (2016), provide compelling evidence that population density should be an important consideration when examining birthplace effects. This is not to say that analysing population density is superior to population size; rather, it indicates that other factors ought to be considered beyond the number of people who inhabit an arbitrary geographic boundary. These other factors might include the eight contextual features of communities that promote positive youth development and talent in sport: (1) physical/psychological safety; (2) appropriate structure; (3) supportive relationships; (4) opportunities to belong; (5) positive social norms; (6) efficacy support; (7) opportunities for skill building; and (8) integration of family, school and community (MacDonald et al., 2009; National Research Council and Institute of Medicine, 2002). It has been suggested that these eight features are more prevalent in smaller communities (e.g., Bale, 2003; Côté et al., 2007; Hancock & Côté, 2014; Kyttä, 2002). In support, less-densely populated areas (regardless of population size) are safer (e.g., have lower crime rates; Harries, 2006; Nolan, 2004), have opportunities for positive social norms (e.g., social development; Dempsey et al., 2012; Lawson, 2010; Raman, 2010), and have opportunities for skill building (e.g., access to green spaces; Fuller & Gaston, 2009).

Rossing et al. (2016) highlighted many of these contextual factors. They emphasised that city structure (i.e., population density) is more important than population size, as it provides favourable talent development opportunities. This could include access to facilities, which in Denmark (the location of Rossing et al. study), favours athletes from less dense communities who have access to more facilities per capita (Kaas, 2013). In cases where birthplace effects' trends did not align with research-based expectations, Rossing et al. (2016) suggested that it has less to do with the city's structure, and more to do with the sport's culture. For instance, in countries with rich soccer histories, athletes in large, high-density cities might receive the same financial and community support as those athletes in smaller cities, possibly because of shared community pride that stems from a club-based soccer system. Such a hypothesis helps understand the unexpected result for women Portuguese volleyball players. Specifically, volleyball is the second-most practised sport (behind soccer) for Portuguese women. This has led to a strong volleyball culture and tradition throughout the country, which might transcend cities of varying population densities. Thus, it seems that total population and population density (and the underlying mechanisms to which they contribute) play important roles in understanding birthplace effects.

Considering this interaction further, perhaps there is an ideal population size and density for developing talented athletes. To excel in sport, athletes must have access to appropriate infrastructure, such as facilities, coaches and teams. This infrastructure, however, ought not to be overly stratified based on competitive standard (Turnnidge et al., 2014), which can negatively impact talent development through burnout and dropout (Fraser-Thomas, Côté, & MacDonald, 2010). This balance in infrastructure is often met in mid-sized cities (Côté et al., 2006; MacDonald et al., 2009; Turnnidge et al., 2014). In addition to infrastructure, athletes require appropriate social structure to attain expertise. It is here that population density plays an important role.

A major consideration is the effect of population density on access to resources in terms of availability and safe use. For the former, low-density European cities have more green spaces (Fuller & Gaston, 2009), and public green spaces are positively associated with increased physical activity among children (Davison & Lawson, 2006). While we cannot state that public green spaces are a requisite for talent development, such spaces might facilitate the process. Residents, however, might not use public green spaces if they feel unsafe. There is a positive relationship between population density and crime rates (Harries, 2006; Nolan, 2004); thus, it is possible that high-density cities have a negative impact on deliberate sport play (Côté, 1999), as residents might feel unsafe using public resources, which could contribute to long-term performance decrements in that city. Indeed, crime reduces physical activity (e.g., Davison & Lawson, 2006; Foster & Giles-Corti, 2008), though some researchers suggest that perception of crime is more of a deterrent for physical activity than actual crime (e.g., Prezza & Pacilli, 2007). Here, the authors noted that in high-crime areas, if residents did not have a fear of crime, physical activity rates were unaffected. These findings might explain why some high-density, high-crime cities produce a disproportionate number of talented athletes (e.g., Brazilian favelas; Coyle, 2009), though this is tentative and warrants further investigation. Collectively, the evidence indicates that less-densely populated areas provide a social structure that facilitates positive benefits for athletic development. We suggest future researchers investigate optimal city size that affords the appropriate infrastructure for talent development, but also ideal population density that offers the requisite social structure.

Integrating this hypothesis with the results herein, it is plausible that for Portuguese volleyball players (men and women), districts sizes of 200,000–399,999 provide the necessary infrastructure for success. For men players, perhaps the less-densely populated areas afford them an appropriate social structure for development. Curiously, though the results for women athletes did not differ, the trend indicated expertise increased as population density increased. This trend could be attributable to several reasons: (1) different social structures in place for women athletes (i.e., regardless of population density, men might be provided more opportunities for free play than women); (2) social structure is less important than infrastructure for women athletes because of fewer participants; or (3) a statistical anomaly specific to the studied country. Further research is required to explicate these results.

Notwithstanding, two limitations must be addressed. First, the present study did not include youth players, which might provide additional insights into how birthplace impacts talent development and talent yield (Woolcock & Burke, 2013). As such, it is important that future researchers consider systematic analysis of population size and density across a larger age range. Second, a challenge in birthplace-effects studies is the use of population categories. We created five population categories, but in each district, there could have been sizeable variations in population density. Researchers ought to explore methods by which to limit such variability, enabling stronger within-category consistency.

Conclusion

The results highlight the complexity of birthplace effects. Additional studies of these effects are warranted, especially to delineate the contributions of city size/infrastructure and population density/social structure. Such a study might involve an epidemiological approach, accounting for the infrastructure and social structure of geographically diverse cities. It is also important to consider how to create studies that might be generalisable across countries and cultures (that is a challenge in birthplace-effects' literature). These ideal investigations might examine city density to country density ratios, facilities per capita or green spaces per capita, all with the intent of improving understanding of how a city's internal structure contributes to success. Until such time as an appropriate study can be conducted, we believe it would be remiss to consider population size or population density in isolation.

Disclosure statement

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