



Original Article

Attractiveness is positively related to World Cup performance in male, but not female, biathletes

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Whole-organism performance capacity is thought to play a key role in sexual selection, through its impacts on both intrasexual competition and intersexual mate choice. Based on data from elite sports, several studies have reported a positive association between facial attractiveness and athletic performance in humans, leading to claims that facial correlates of sporting prowess in men reveal heritable or nonheritable mate quality. However, for most of the sports studied (soccer, ice hockey, American football, and cycling), it is not possible to separate individual performance from team performance. Here, using photographs of athletes who compete annually in a multi-event World Cup, we examine the relationship between facial attractiveness and individual career-best performance metrics in the biathlon, a multidisciplinary sport that combines target shooting and cross-country skiing. Unlike all previous studies, which considered only male athletes, we report relationships for both sportsmen and sportswomen. As predicted by evolutionary arguments, we found that male athletes were judged more attractive if (unknown to the raters) they had achieved a higher peak performance (World Cup points score) in their career, whereas there was no significant relationship for female biathletes. Our findings show that elite male athletes display visible, attractive cues that reliably reflect their athletic performance.

Key words: endurance, evolutionary sports science, fWHR, mouth curvature, sexual signaling, whole-organism performance.

INTRODUCTION

The evolution of mating preferences for indicators of direct or indirect fitness benefits is fundamental to all major theories of sexual selection (Kokko et al. 2006; Kuijper et al. 2012). Although most research has focused on preferences for morphological “ornaments” such as enlarged appendages or bright color patches (Andersson 1994; Andersson and Simmons 2006), evidence suggests that mating patterns are also influenced by behavioral and physiological characteristics, through their effects on whole-organism performance (Lailvaux and Irschick 2006; Husak and Fox 2008; Lailvaux and Husak 2014). Individual variation in performance can influence both intrasexual and intersexual interactions. In some animals, athletic ability (e.g., endurance, sprint speed) predicts the outcome of intrasexual competition, which in turn determines access to mating opportunities (e.g., beetles, crustaceans, and lizards; reviewed in Lailvaux and Irschick 2006). In others, courtship behavior directed towards the opposite sex involves active displays of maximum power output, motor skill, or stamina and these

performance measures are associated with higher mating success (e.g., Anna’s hummingbirds, *Calypste anna*, Clark 2009; golden-collared manakins, *Manacus vitellinus*, Barske et al. 2011; Cuban burrowing cockroaches, *Byrsotria fumigata*, Mowles and Jepson 2015).

Competitive sport offers a unique setting in which to examine some of these issues in our own species. Recent studies on a range of different sports have suggested that women are attracted to men with higher sporting ability, based purely on static images of their face and upper shoulders. When shown facial photographs of elite sportsmen, women gave higher attractiveness ratings to National Football League quarterbacks with better passer ratings (Williams et al. 2010), cyclists who achieved a higher finishing position in the 2012 Tour de France (Postma 2014) and mixed martial artists who had won their bouts (Little et al. 2015). A study on soccer and ice hockey (Park et al. 2007) also reported higher attractiveness ratings for men who play in arguably more athletically demanding positions (strikers, goalkeepers/goalies) than those in other positions (defenders/defensemen), although detailed analysis of the workload in different soccer positions suggests a more complex picture (Bloomfield et al. 2007; Gil et al. 2007). While facial

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attractiveness is unlikely to have a direct impact on success in any of these sports, it has been suggested that facial cues to sporting performance could arise through multiple effects of testosterone and other androgens (Williams et al. 2010; Tsujimura and Banissy 2013; Zilioli et al. 2015). Androgens have been linked both to the development of facial structure during puberty (Weston et al. 2007) and to behavior in competitive interactions (Eisenegger et al. 2011; Oliveira and Oliveira 2014), though direct evidence for a common mechanism is weak at best (Bird et al. 2016).

According to evolutionary arguments, a female preference for more athletic men was selectively favored in our recent evolutionary past because pairing with such men offered direct or indirect benefits (Williams et al. 2010; Postma 2014; Longman et al. 2015). Such arguments are perhaps most relevant for endurance, that is, sustained activity over long distances, which may have been an important determinant of foraging (hunting or scavenging) success in ancestral environments and for which humans have an unusual capacity among mammals (Carrier 1984; Bramble and Lieberman 2004; Lieberman and Bramble 2007). However, the extension of this evolutionary logic to performance in elite sports, and the empirical evidence proposed to support it, is hotly debated. Critics have argued that the reported effect sizes are weak, that findings from homogeneous groups of elite athletes cannot be generalized to the wider human population and that available performance metrics reflect variation in sport-specific training rather than biological indicators of heritable fitness (Smoliga and Zavorsky 2015, 2016; see counter-arguments in Postma 2016). Although the genetic basis of variation in elite athletic performance is disputed (Postma 2016, Smoliga and Zavorsky 2016), this debate overlooks a crucial point: a preference for more athletic males could evolve even if athleticism is not heritable. Indeed, one general conclusion from models of sexual selection is that preferences for direct (i.e., nongenetic) benefits typically evolve more easily than those for indirect (i.e., genetic) benefits (Kokko et al. 2006; Kuijper et al. 2012).

There are, however, other important limitations of much of the published research on attractiveness and sporting ability. First, performance in team sports (e.g., American football, soccer, and ice hockey) is strongly dependent on the behavior of other individuals (i.e., the focal individual's team mates). Even the Tour de France, which superficially may seem like an individual sport, has a well-known strategic, team-based element (Torgler 2007) that partly determines finishing positions in a given year. Although it seems likely that individual performance capacity would have partly contributed to the measured outcomes in these studies, a purer measure of athletic performance could be obtained by using an individual-level sport in which there is no team element.

A second limitation, specific to Postma's (2014) Tour de France study, is that attractiveness ratings may have been influenced by the raters' knowledge of the research aims. The online advertisement recruiting participants for this study explicitly stated that the aim was to investigate "the relationship between looks and performance" using "the portraits of professional cyclists that have taken part in the 2012 Tour de France" (Postma 2012). It is possible, therefore, that the reported relationship could have been driven by demand characteristics (Orne 1962) leading participants to associate more athletic-looking faces with higher attractiveness. To demonstrate a valid preference for more athletic individuals that is not driven by demand characteristics, it is important that explicit information about the sporting context is hidden from raters.

Finally, all previous studies have focused entirely on the relationship between facial attractiveness and sporting performance in male athletes, ignoring whether a similar relationship exists for female

athletes. If the evolutionary explanation for this relationship is credible—that an ancestral preference for more athletic mates led to direct or indirect fitness benefits—then there are reasons to expect that the relationship will be different for females. Evidence suggests that in our recent evolutionary past, it was primarily men rather than women who engaged in hunting activities (Hawkes and Bliege Bird 2002; Marlowe 2007); the potential benefits for a man choosing a more athletic partner are less clear. In addition, the proposed role of testosterone as a mechanistic link between facial characteristics and athletic performance is more plausible for men than for women, given that the sexual divergence of human facial structure (Weston et al. 2007) and neuromuscular performance (Beunen and Malina 1988) coincides with a pubertal surge in testosterone production in men (Verdonck et al. 1999). For these reasons, we would expect the relationship between facial attractiveness and sporting performance to be weaker or even nonexistent in women, compared to men. Examining the relationships for both sexes would therefore allow a more comprehensive test of evolutionary predictions.

Here, we report a study that addresses all the above limitations. For the first time, we determine the relationship between facial attractiveness and sporting performance in both male and female athletes in an individual-based sport without any team element, using attractiveness judgments made by raters who were unaware of the sporting connection. We focus on the biathlon, a cross-country skiing race interspersed with rounds of target shooting that tests elements of both endurance and skill. Cross-country skiing requires a large amount of aerobic power, muscle strength (Neumayr et al. 2003), balance (Müller et al. 2011), coordination, and endurance (Stoggl et al. 2010), while shooting requires the ability to compose oneself via breathing techniques so that the physiological demands of the skiing do not affect shooting accuracy (Sattlecker et al. 2007). The International Biathlon Union organizes an annual series of World Cup events in which men compete over distances of 10–20 km and women over 7.5–15 km, generating individual performance metrics each year for the top international competitors of both sexes. Independently, we obtained opposite-sex attractiveness ratings for facial photographs of World Cup biathletes from a sample of participants in the United Kingdom, where biathlon is not widely followed and therefore we could be confident that the ratings were not influenced by a perceived connection to sport.

METHODS

Athletes

We obtained data on all 173 athletes (89 men aged 19–38 years; 84 women aged 22–40 years) who competed in the biathlon at the 2014 Winter Olympic Games in Sochi, Russia. Passport-style photographs were downloaded from the Russian sports website P-Cropt (R-Sport; archived at <http://sochi2014.arch.articul.ru/www.sochi2014.com/en/biathlon-athletes.htm>) and rescaled to a standard size (144 × 80 pixels). We discarded 23 photos (12 male, 11 female) that were of poor quality, or had features that potentially identified the subject as an athlete (e.g., national sports kit), or for whom performance data were unavailable. This left us with a sample of 78 male and 78 female photos, depicting only the head, neck, and upper shoulders of the athlete, evenly lit against a plain background and directly facing the camera. We took 2 sets of measurements from these photos that previous research suggests may influence ratings of attractiveness and dominance: facial width-to-height ratio (fWHR; Figure 1a), calculated as the bizygomatic width (distance between left and right cheekbones at

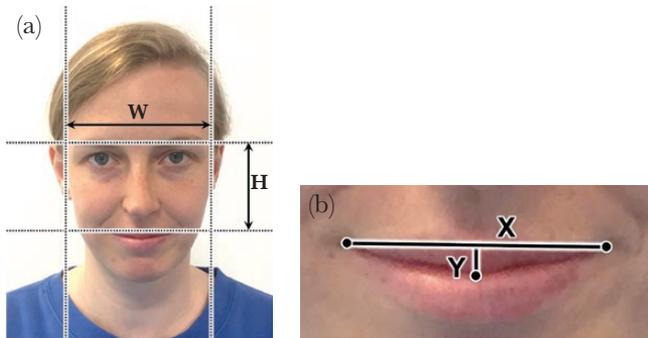


Figure 1 Measurement of (a) facial width-to-height ratio (fWHR) and (b) mouth curvature from portrait photographs. We calculated fWHR as W/H (following Weston et al. 2007), where W is the bizygomatic width (distance between left and right cheekbones at the widest part of the face) and H is the upper facial height (distance between upper lip and brow). We calculated mouth curvature as Y/X (following Talamas et al. 2016), where Y is the upturn of the mouth (vertical distance from mouth center to left and right corners) and X is the mouth width (distance between left and right corners). Note that this image does not depict one of the biathletes used in this study, but is shown purely for illustrative purposes.

the widest part of the face) divided by the upper facial height (distance between upper lip and brow) (Weston et al. 2007; Carré and McCormick 2008); and mouth curvature (Figure 1b), calculated as the upturn of the mouth (vertical distance from mouth center to left and right corners) divided by the mouth width (distance between left and right corners) (Talamas et al. 2016). We obtained the date of birth, height, and weight for all of these athletes from the P-Спорт website.

To assess performance, we used the “World Cup total score” as defined by the International Biathlon Union (2016; section 15.8.4.1). This total, recalculated each season, comprises the points scored in all individual, nonrelay World Cup events (“individual,” “sprint,” “pursuit,” and “mass start”), minus the 2 lowest scores; note that team-based events (“relay” and “mixed relay”) are excluded. The scoring system awards 60 points for winning a race and gradually decreasing points down to 40th place (for full details, see International Biathlon Union 2016). We recorded each athlete’s World Cup total score in every season from 2001–2002 to 2013–2014 inclusive, as archived on the International Biathlon Union’s Datacenter (<http://biathlonresults.com>) and another biathlon statistics website (<http://www.realbiathlon.com>), and then took the highest score for each athlete as a measure of their career-best performance.

Raters

To rate the attractiveness of the athletes, we recruited 25 male and 25 female participants (mean age 21.3 years, range 17–58) via e-mail, social media, and opportunity sampling around the University of Bristol campus; most were undergraduate students. This number of raters is comparable to several previous studies using facial attractiveness judgments (e.g., $n = 21$ in Penton-Voak et al. 2001; $n = 28$ in Penton-Voak and Chang 2008; $n = 30$ in Williams et al. 2010; $n = 33$ in Little et al. 2015). Participation in the study was completely voluntary and no payment was offered.

Procedure

Participants were taken to a test room in the University of Bristol’s Life Sciences Building, where they read and signed a consent

form that provided basic information about the testing procedure (without revealing the study’s aims or the connection to sport) and explained that they were free to withdraw at any stage. They then completed (at their own pace) a series of questions using keystrokes on a laptop computer, presented using E-Prime software version 2.0 (Psychology Software Tools 2002). After confirming their sex and age, the participants were shown the photos of opposite-sex biathletes in randomized order and asked to indicate 1) how physically attractive they found that person on a scale from 1 (very unattractive) to 7 (very attractive) and 2) whether they recognized the person. At the end of the study, they were asked to indicate their sexual orientation. All details of the procedure were approved by the University of Bristol Research Ethics Committee (ref. 12741).

Statistical analysis

One male rater identified himself as homosexual at the end of the task; so, his ratings were omitted before analysis. We also omitted 76 cases (less than 2% of the sample; no more than 3 cases for any athlete) where the rater reported that they recognized the face, even though when probed by the experimenter none of these correctly identified that the faces belonged to elite athletes. This left us with a sample of $n = 3746$ attractiveness scores for 78 male and 78 female biathletes, rated by 24 male and 25 female participants. Including all of the data ($n = 3900$) did not change the patterns reported here (Supplementary Tables S3 and S4). The results were also the same when excluding the small number (6 women and 3 men) of non-Caucasian biathletes (Supplementary Tables S5 and S6).

To analyze the factors affecting the variation in attractiveness ratings, we ran a series of linear mixed-effects models (LMMs) using the packages *lme4* (Bates et al. 2015) and *lmerTest* (Kuznetsova et al. 2015) in R version 3.5.1 (R Core Team 2018). In all models, the athlete and rater identities were included as random effects to account for nonindependent ratings. First, we fitted a model to the attractiveness data for both sexes combined, with fixed effects of athlete performance (highest World Cup total score), sex, age, height, body mass index (BMI = weight [kg] divided by height [m] squared), and a 2-way interaction term between athlete sex and performance. BMI was used in place of weight to reduce problems with multicollinearity, given that weight and height measurements are very strongly correlated (44.0% shared variance between weight and height in female biathletes and 64.0% in male biathletes, compared to 3.4% and 1.7%, respectively, between BMI and height). Before analysis, the response variable (attractiveness rating) and all continuous predictors (age, height, BMI, and performance) were converted to Z scores (i.e., standardized) within each sex by subtracting the mean and dividing by the standard deviation for that sex. We included both linear and quadratic terms for the effects of age, height, and BMI. Because the sex \times performance interaction term was significant, we then analyzed the data for each sex separately. Finally, we checked whether the observed relationships were mediated by mouth curvature or fWHR by including these measurements (also converted to Z scores) as additional predictors in the model.

The models were fitted using restricted maximum likelihood and the significance of fixed effects was assessed using Wald t tests with Satterthwaite-approximated degrees of freedom. Where significant effects were found, we used likelihood-ratio tests (based on maximum likelihood estimation) to check whether the inclusion of random slopes (varying with rater identity) improved the fit of the model. Residual plots confirmed assumptions of normality and homoscedasticity for all models.

The full data set and R code are available as [Supplementary Information](#) archived in the Dryad digital repository (Fawcett et al. 2019).

RESULTS

Raters varied significantly in the mean attractiveness rating they gave (random effect of rater identity, explaining 30.5% of the variation in ratings; LMM: $\chi^2_1 = 1820.9$, $P < 0.001$). Despite this, there was significant variation among biathletes in their mean rated attractiveness (random effect of athlete identity, explaining 29.4% of variation; LMM: $\chi^2_1 = 1659.3$, $P < 0.001$) and the raters showed strong agreement overall in which biathletes they found attractive (intra-class correlation $r = 0.838$, based on variance components from 1-way analysis of variance).

A model for both sexes combined, controlling for age, height, and BMI, revealed that the relationship between attractiveness and sporting performance (career-best World Cup total score) differed significantly between male and female biathletes (sex \times performance interaction term: $P = 0.010$; Table 1). There was also significant variation among individual raters in how their ratings were related to athlete performance (random slope term, explaining 0.5% of variation; $\chi^2_2 = 14.2$, $P = 0.001$). To decompose the sex \times performance interaction term, we subsequently analyzed the sexes separately (Table 2). Among female biathletes, attractiveness ratings declined significantly with age, but there was no effect of performance (Table 2, Figure 2a). By contrast, male biathletes who had achieved a higher World Cup total score in their career were rated as significantly more attractive (Table 2, Figure 2b). All quadratic terms were nonsignificant (Supplementary Table S1), so were omitted from the final models shown here. This pattern of results matches evolutionary predictions, suggesting that women are sensitive to cues that reliably indicate athletic ability in men.

Previous work (Williams et al. 2010; Tsujimura and Banissy 2013; Zilioli et al. 2015) has suggested that sporting performance might covary with differences in facial structure linked to androgens. For our data set, however, although fWHR was positively related to sporting performance in male biathletes (linear regression: $b \pm SE = 0.236 \pm 0.113$, $t_{70} = 2.08$, $P = 0.041$), this morphological measure did not predict their facial attractiveness ratings (LMM: $b \pm SE = 0.023 \pm 0.066$, $t_{66.2} = 0.35$, $P = 0.730$). Another possibility is that athletic ability is revealed not by facial structure but by facial expression, reflecting an athlete's confidence or past success. We found that mouth curvature (a proxy for smiling; Talamas

et al. 2016) was negatively related to sporting performance in male biathletes (linear regression: $b \pm SE = -0.319 \pm 0.122$, $t_{70} = -2.62$, $P = 0.011$), but again did not predict their facial attractiveness ratings (LMM: $b \pm SE = 0.067 \pm 0.072$, $t_{65.9} = 0.94$, $P = 0.353$). Importantly, including fWHR and mouth curvature in our earlier models did not alter the pattern of other effects: as before, facial attractiveness was positively related to performance in male (LMM: $b \pm SE = 0.160 \pm 0.071$, $t_{72.4} = 2.27$, $P = 0.026$), but not female (LMM: $b \pm SE = 0.011 \pm 0.077$, $t_{66.0} = 0.14$, $P = 0.888$), biathletes (Supplementary Table S2).

DISCUSSION

Our analysis shows that male biathletes who had achieved a higher World Cup total score in their career were judged as more attractive by the opposite sex based solely on a photograph of their face and upper shoulders, whereas there was no such relationship for female biathletes. These patterns hold when controlling for age, height, and BMI. Previous studies have shown that attractiveness ratings are higher for elite sportsmen who won their last mixed martial arts bout (Little et al. 2015) or achieved a higher finishing position in the 2012 Tour de France cycling race (Postma 2014), while ours shows that attractiveness is also linked to career-best performance in an annual competition in which individuals are "playing the field," without any dyadic or strategic team-based element. Most importantly, our study is the first to examine this relationship in both sexes and show that it only exists for male athletes. By keeping the sports connection hidden from raters, we ensured that the observed relationships could not be driven by demand characteristics. Our results therefore provide strong evidence that photographs of successful male athletes contain cues that are attractive to the opposite sex.

There are at least 4 possible explanations for these results. The first possibility is that, as suggested by some evolutionary hypotheses based on intersexual selection, more athletic men have physical characteristics that reliably signal their greater performance capacity, and women are attuned to those characteristics because in ancestral environments they predicted direct or indirect fitness benefits (Williams et al. 2010; Postma 2014; Longman et al. 2015).

Table 2

Estimates of fixed effects in a linear mixed-effects model predicting opposite-sex attractiveness ratings separately for (a) female and (b) male biathletes

Fixed effect	Estimate \pm SE	<i>t</i>	df*	<i>P</i>
<i>(a) women (n = 78)</i>				
Intercept	0.006 \pm 0.129	0.05	38.9	0.964
Age[†]	-0.209 \pm 0.078	-2.69	76.2	0.009
Height	0.016 \pm 0.070	0.24	73.0	0.814
BMI	-0.060 \pm 0.069	-0.87	72.9	0.388
Performance	-0.007 \pm 0.077	-0.09	73.0	0.933
<i>(b) men (n = 78)</i>				
Intercept	-0.008 \pm 0.127	-0.07	37.3	0.947
Age	-0.017 \pm 0.063	-0.27	73.0	0.789
Height	0.000 \pm 0.062	0.01	72.9	0.995
BMI	0.109 \pm 0.062	1.77	72.9	0.081
Performance[‡]	0.159 \pm 0.065	2.45	81.3	0.017

Significant effects ($P < 0.05$) highlighted in bold.

*Denominator degrees of freedom derived using Satterthwaite approximation.

[†]Slope varies significantly among raters ($\chi^2_2 = 10.6$, $P = 0.005$).

[‡]Slope varies significantly among raters ($\chi^2_2 = 16.3$, $P < 0.001$).

Table 1

Estimates of fixed effects in a linear mixed-effects model predicting opposite-sex attractiveness ratings for biathletes (both sexes, n = 156)

Fixed effect	Estimate \pm SE	<i>t</i>	df*	<i>P</i>
Intercept	0.006 \pm 0.129	0.05	76.5	0.964
Sex (male)	-0.014 \pm 0.182	-0.08	77.2	0.938
Age	-0.085 \pm 0.049	-1.74	148.9	0.084
Height	0.011 \pm 0.047	0.23	148.8	0.820
BMI	0.043 \pm 0.046	0.93	148.8	0.353
Performance [†]	-0.070 \pm 0.070	-1.00	159.0	0.319
Sex \times performance	0.245 \pm 0.094	2.61	159.3	0.010

Significant effects ($P < 0.05$) highlighted in bold.

*Denominator degrees of freedom derived using Satterthwaite approximation.

[†]slope varies significantly among raters ($\chi^2_2 = 14.2$, $P = 0.001$).

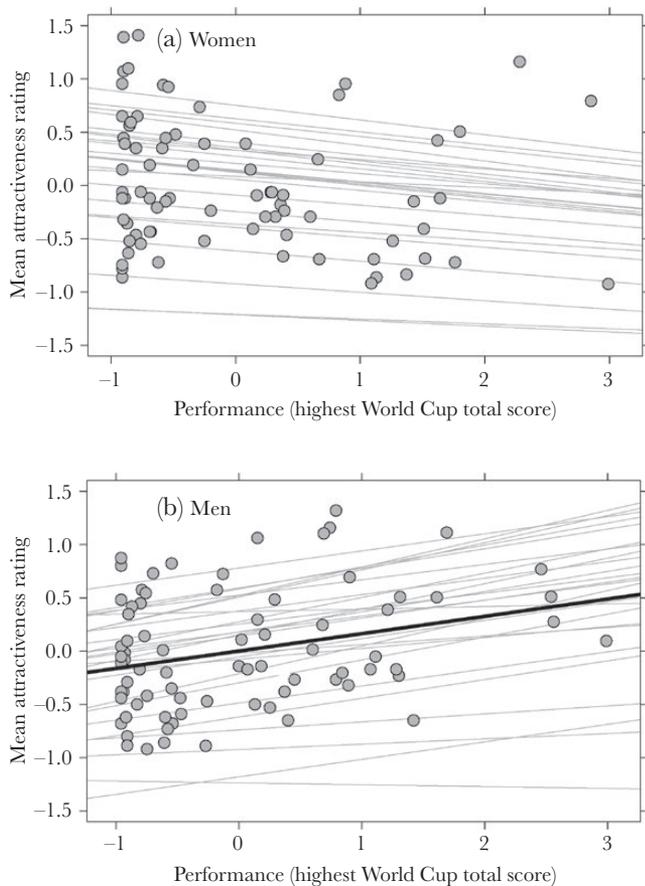


Figure 2

Mean standardized attractiveness of (a) female and (b) male biathletes as rated by the opposite sex, in relation to their career-best performance (highest World Cup total score). Dots represent individual athletes. The thick black line in panel (b) shows the significant ($P = 0.017$) positive relationship between performance and attractiveness in male biathletes from a linear mixed-effects model controlling for age, height and body mass index, with random intercepts for athlete and rater identity and a random slope term (varying among raters) for the effect of performance (rater-specific relationships shown as thin grey lines). The corresponding relationship was nonsignificant ($P = 0.933$) for female biathletes.

For this hypothesis to work requires that athletes varying in their performance measures show perceptible differences in features of the head (including face), neck or upper shoulders in static photographs, given that this was the only information seen by our participants. As a candidate cue we examined fWHR, a sexually dimorphic measure possibly linked to hormonal changes during puberty (Verdonck et al. 1999; Carré and McCormick 2008) and correlated with aggressive behavior (Carré and McCormick 2008; Carré et al. 2009), the outcome of violent conflicts (Stirrat et al. 2012; Zilioli 2015), and sporting success (Tsujiyura and Banissy, but see Mayew 2013). A meta-analysis of studies investigating fWHR concluded that it influences ratings of dominance or threat and, to a lesser extent, ratings of attractiveness (Geniole et al. 2015). In our data set, fWHR was positively related to peak performance in male biathletes but not to their rated attractiveness, and including it as a predictor in our statistical models did not explain the observed relationship between performance and attractiveness. There may well be other cues besides fWHR in the face, neck or upper shoulders that are consistently related to athletic performance; further work

using more detailed morphometric comparisons would be needed to identify what these cues might be.

A second possible explanation is that success in World Cup events is reflected in an athlete's facial expression, which in turn influences their attractiveness to the opposite sex. For example, athletes who perform better than their rivals may be happier or more confident, either as a direct result of their success (e.g., good performances lead to higher confidence and more positive mood states) or because pre-existing differences in confidence have an important influence on outcomes in elite sport (Moritz et al. 2000; Feltz 2007; Hays et al. 2009), perhaps particularly in men (Woodman and Hardy 2003). To investigate this possibility, we quantified mouth curvature, a measure of facial expression indicative of smiling (Talamas et al. 2016). Previous research suggests that smiling can enhance attractiveness (Jones et al. 2006; Golle et al. 2014), but perhaps only in women, with a neutral (Penton-Voak and Chang 2008) or even negative (Tracy and Beall 2011) effect of smiling on male attractiveness. In our study, including mouth curvature as an additional predictor did not account for the observed relationship between performance and attractiveness in men, despite a significant negative relationship between mouth curvature and performance. Future work analyzing a more extensive set of feature point coordinates (Benson and Perrett 1991; Tiddeman et al. 2001) may reveal subtler differences in facial expression that potentially influence attractiveness judgments.

A third possibility is that athletes who are judged more facially attractive receive more support and investment from an early age, ultimately leading to an improved career performance compared to less attractive athletes. Studies suggest that attractive people are treated more favorably than less attractive people in a range of contexts, leading to better economic prospects, a greater chance of being hired for jobs and even more affectionate interactions with their mothers (Langlois et al. 2000; Little 2014). Such advantages could extend into the sporting domain if, for example, better-looking athletes are more likely to be selected for high-performance programs, receive extra attention from coaching staff, and secure lucrative sponsorship deals, potentially enhancing their career performance. While intriguing, we consider this to be an unlikely explanation for our results, because if anything it would predict that the positive relationship between sporting performance and facial attractiveness should be stronger in female than male athletes. Sports coaching is dominated by men (Knoppers 1992; Walker and Bopp 2011) and much has been written about the power of male coaches over their athletes (Brackenridge 1997; Fasting and Brackenridge 2009), particularly the circumstances under which this power can be exploited and lead to sexual harassment or abuse of female athletes (Cense and Brackenridge 2001; Nielsen 2001; Fasting et al. 2003, 2004). Furthermore, while biased investment in more attractive athletes may have a strong influence on progression to elite level, the impact on performance outcomes among those who have successfully made it to that level is likely to be much weaker. Nonetheless, investigating attractiveness biases in sport would be a valuable direction for future work. Evidence from the German Bundesliga suggests that a footballer's market value is enhanced by his facial attractiveness, independent of actual performance ratings (Rosar et al. 2017), but to our knowledge, no studies have addressed whether coaching behavior and other aspects of athlete development are affected by physical attractiveness, in either sex.

A final possibility is that more successful athletes spend more time, effort and money enhancing their attractiveness through personal grooming, cosmetic surgery or other means. We were unable to control for the use of make-up in the images, although it is

important to note that these were fairly standardized, passport-style photographs rather than publicity shots. While this explanation could potentially apply to some higher-profile sports in which success generates fame, with accompanying publicity and advertising deals, it seems unlikely to explain our results here, particularly given the absence of an effect in women. Nonetheless, future studies could improve on our methodology by ensuring greater standardization of the photos (e.g., covering of hair, no make-up).

Our study complements related findings in Tour de France cyclists (Postma 2014) and mixed martial artists (Little et al. 2015) and adds to the nascent field of evolutionary sports science (Wilson et al. 2017), highlighting the value of sports data as a rich resource for investigating how selection acts on psychological and physiological aspects of athletic performance. Using annual performance measures from the biathlon World Cup, we found that male, but not female, biathletes who had achieved a higher career peak were rated as more physically attractive by the opposite sex. This pattern is consistent with the evolutionary hypothesis that a female preference for more athletic men evolved through sexual selection, but also with other potential explanations. Further work is required to identify the specific cues that make better male athletes more attractive and to establish whether those cues directly reveal natural variation in sporting ability, confidence arising from differential success or biased investment in their athletic development.

SUPPLEMENTARY MATERIAL

Supplementary data are available at *Behavioral Ecology* online.

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Ethics: The procedure was reviewed and approved by the University of Bristol Research Ethics Committee (ref. 12741) and informed consent was given by all participating raters.

Competing interests: We have no competing interests.

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Data accessibility: Analyses reported in this article can be reproduced using the data and R code provided by Fawcett et al. (2019).

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