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RESEARCH ARTICLE

Shirts or Skins?: Tattoos as Costly Honest Signals of Fitness and Affiliation among US Intercollegiate Athletes and Other Undergraduates

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Abstract

Body art that lesions the skin can result in infection, making tattoos and piercings inherently risky forms of expression. Evolutionary theorists have posited two complementary hypotheses for the popularity of tattooing and piercing in the face of less dangerous options. The "human canvas hypothesis" suggests that tattooing and piercing may be hard-to-fake conscious or unconscious advertisements of fitness or affiliations. The "upping the ante hypothesis" proposes that tattooing and piercing are costly honest signals of good genes in that they injure the body to show how well it heals. We sampled two student populations in the USA to test three related predictions: (1) intercollegiate athletes would be tattooed and pierced at higher rates than other undergraduates to signal fitness, (2) athletes would be more likely to get college- or pro sports-related tattoos than other students, and (3) tattooed or pierced intercollegiate athletes would have lower rates of tattoo- and piercing-related medical complications. We used chi-square and separate logistic regressions of athlete status on tattooing, piercing, and related complications. Study 1 ($n = 524$) did not find support for predictions but included only a small number of athletes with body modifications. Study 2 ($n = 6004$) found no main effect for athletes but did find an interaction effect for athletes-by-gender ($p = .005$). Athletes were also more likely to have college- and pro sports-related tattoos, and football players and male swimmers/divers were more likely to be tattooed in general than other undergraduates ($p < .05$). Finally, we found positive relationships between tattooing/BMI and BMI/tattooing complications ($p < .01$), supporting a costly honest signaling function irrespective of athlete status. Both hypotheses were falsified for piercing. Our findings support tattooing as a fitness and affiliation signal that is highly context-dependent.

Keywords Tattooing · Piercing · Costly honest signaling · Intercollegiate athletes · Undergraduates · BMI

Introduction

Tattooing and piercing are interesting forms of body decoration because they simultaneously draw attention to the body and injure it. Body decoration is ubiquitous in humans and appears among other organisms as well (Kohler 1925; MacKinnon 1978), which suggests body décor represents a phenotypic gambit (Lynn and Medeiros 2017), or behavior with underlying adaptive functions (Grafen 1991). The many uses and meanings of tattooing and piercing suggest social selection pressures may be operating to maintain their continued practice. Social selection is a type of natural selection that accounts for dynamics of cooperation that maximize reproductive fitness (Roughgarden 2009). As hypothesized for hunting (Hawkes and Bliege Bird 2002), tattooing and piercing may have been used to demonstrate social prestige and maximize fitness (Carmen et al. 2012; Koziel et al. 2010; Lynn and Medeiros 2017; Wohlrab et al. 2009a). We examine tattooing and piercing in a prestigious class of people in a contemporary US setting. By comparing tattooing and piercing in elite athletes to similar non-athletes, we may be able to determine if, indeed, such body modifications help more fit individuals show off their phenotypes and affiliations.

Cultural tattooing and piercing practices go back thousands of years as indicated by these body modifications found on ancient mummies; jewelry and implements found at ancient sites; and sculptures, paintings, and other artifacts that attest to their antiquity (DeMello 2000, 2007; Deter-Wolf et al. 2016; Gilbert 2000). Anthropologists have long speculated that tattooing arose as an

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elaboration of body painting and therapeutic scarification (Hambly 2009 [1925]; Rivers 2001 [1923]). Evidence from the Middle Stone Age in Africa suggests hominid ancestors were processing pigment 280,000 years ago (ya) (McBrearty and Brooks 2000), and materials found at sites in Europe from the Upper Paleolithic (12,000–40,000 ya) may have been used for tattooing (Gilbert 2000; Krutak 2007). Crosses tattooed on Ötzi, the 5300-year-old mummy found frozen in the Alps, suggest ancient therapeutic applications (Krutak 1999; Pabst et al. 2009). Piercing is also found around the world. Numerous examples of ear piercings, plugs, and studs have been found among ancient Egyptian sites. Scythians in the north Black Sea practiced piercing on male and female infants in a manner still observed in India, where piercing ornaments serve various purposes and signal different meanings on different ears (Rush 2005). Some of these modifications have taken place in environments where pathogen exposure is high and may indicate resistance to disease, but others seem connected only to social syntax (Ludvico and Kurland 1995). Contemporary tattooing is highly individualistic and conducted largely in hygienic ways. Evolutionary explanations for tattooing and piercing must therefore rectify this diversity of practices.

Evolutionary Hypotheses for Tattooing and Piercing

The *human canvas* hypothesis proposes that tattooing and piercing have occurred cross-culturally because of the way they integrate human symbolic communication to convey personal or social information (Carmen et al. 2012). In much the same way that the cave paintings in Le Chauvet allowed humans to express symbolic thought 31,000 ya, tattoos and body piercings provide individuals in the modern world with the opportunity to display aspects of their inner psyches to be visible to others. Additionally, the imagery selected for a tattoo can symbolize affiliation with particular groups. These means of communication may seem counterintuitive because of the injury they present the body (Sosis et al. 2007) and the availability of non-invasive cosmetics, body paint, physical training, clothing, hairstyles, and another décor. However, the relative permanence of tattoos and piercing indicate commitment or sincerity that is hard to fake (Bulbulia 2008; Sosis 2006).

The *upping the ante* hypothesis suggests that, while non-invasive body décor may obscure signs that a person is less than fit (e.g., hiding skin blemishes), tattoos and piercings actually challenge the body's immune system by increasing vulnerability to infection and ability to recover (Carmen et al. 2012). When poker players "up the ante," they are raising the stakes and taking risks. In some cases, this is because players are holding great hands of cards, so the increased bets demonstrate honest signals of the quality of the cards. In other cases, players may be bluffing and do not actually possess the cards to back up the bets they are making (i.e., dishonest signals). Modern sanitation and hygiene standards for tattooing and piercing in many developed countries are high, and infection rates are low; however, safety regulations and enforcement are inconsistent, and serious infections do occur (Kluger and Koljonen 2012; Kluger et al. 2013; Laux et al. 2015; Wohlrab et al. 2009b). Thus, these practices can also be seen as upping the ante or handicapping the individual for fitness displays (Wohlrab et al. 2009a). Successful tattoos and piercings may indicate fitness, such as through pain tolerance or resistance to infection. On the other hand, trying to bluff about fitness through body modifications can backfire. For instance, immunodeficient individuals have higher risks of developing complications from tattooing, or individuals with few tattoos who use numbing creams may be scorned in the tattooing community. The idea that people need to "earn" tattoos by experiencing the pain is viewed as being cheated by numbing cream (e.g., http://www.bigtattooplanet.com/forums/tattoo-talk/17245-numbing-cream-against). In both cases, individuals gamble on their body modification displays increasing their fitness.

Tattooing and piercing have been specifically linked to individual identity formation (Edgerton and Dingman 1963; Horne et al. 2007; Stirn 2007; Sweetman 1999). Several studies have indicated high rates of tattooing and piercing among undergraduate college students (Forbes 2001; Horne et al. 2007; King and Vidourek 2013; Manuel and Sheehan 2007; Mayers et al. 2002; Mayers and Chiffriller 2008; Resenhoeft et al. 2008), who are in the prime years of forming self-identities. These body modifications are increasingly acceptable aspects of mainstream identity, as studies of tattooing in the labor force suggest. Tattoos may even be considered an asset if they are generally associated with the occupation (for instance, if the occupation brands itself as "edgy") (Timming 2017), as they are with some professional athletics (Kluger 2015).

Furthermore, studies of coalitional psychology in sports suggest that the in-group loyalty, intergroup competition, and interest and economy that grow up around teams (i.e., sports fandom) are exaptations of cognitive dispositions evolved for small-scale warfare (Deaner et al. 2012; Kniffin and Sugiyama 2018; Kruger et al. 2018; Lombardo 2012; Sugiyama et al. 2018; Winegard and Deaner 2010). Humans are sensitive to markers of such alliances and visual symbols of them, especially to successful coalitions and the commensurate benefits of or being associated with success (Kruger et al. 2018; Winegard and Deaner 2010). Marks that signify winners, like sports jerseys or the more permanent tribute of a tattoo, may be worn by others to ally themselves with those winners, which said winners may allow or encourage because it appears prosocial and enhances the reputations of such winners (Barbaro et al. 2018).

Are Tattoos and Piercings Fitness Indicators?

Few studies have examined whether elite groups such as highly trained athletes are more likely to take the "risk" to advertise their phenotype or status through tattooing and piercing, though some have linked tattooing in general with advertising fitness. Koziel et al. (2010) found tattooing positively associated with bilateral symmetry, an indication of developmental health and vigor. Mayers and colleagues (2002; Mayers and Chiffriller 2008) conducted two prevalence studies of tattooing and piercing in US undergraduates and compared athletes to non-athletes within the samples. In the first study ($n = 481$), they found that male athletes were more likely to be tattooed than male non-athletes but no such difference in females (Mayers et al. 2002). However, in a follow-up ($n = 650$) at the same upstate New York institution, there were no differences among any groups (Mayers and Chiffriller 2008). Similarly, a study of 997 Black and Hispanic US student-athletes awaiting pre-participation sports exams found relatively low rates of men (10%) and women (6%) were tattooed (Benjamins et al. 2006). These studies provide mixed support for the human canvas hypothesis. To test for a role of tattooing as an indicator of fitness beyond drawing attention to the body, Lynn et al. (2016) compared tattooing experience to biomarkers of stress and immune response and found that normal stress-induced immunosuppression while being tattooed is relaxed in individuals with high tattoo experience, suggesting an upping the ante effect. However, the sample was small, mostly women, and did not indicate whether heavy tattooing primed this effect or was simply more likely among people with better immune systems.

Hypotheses Development

The current study extends this research by testing the human canvas and upping the ante hypotheses among undergraduates across the USA and at a flagship state research institution with a large intercollegiate athletic program. We predict that intercollegiate athletes (ICAs) will (1) be tattooed at a higher rate than other undergraduates to draw attention to their fitness, (2) be more likely than other undergraduates to signal their athletic affiliation with college or sports tattoos, and (3) have lower rates of tattoo- and piercing-related medical complications than other undergraduates because of their enhanced fitness.

Prediction 1 As scholars have noted, there are distinctive gender differences in participation, performance, observation, and resource command of sports cross-culturally. These differences suggest a role of competitive athletics—or, more generally, physical "contests"—in sexual selection, competition for status, training for combat and hunting, or a combination of these (De De Block and Dewitte 2009; Deaner et al. 2012; Kurzban and Leary 2001; Lombardo 2012; Miller 2001; Van Vugt 2009). Studies suggest that people consider athletes more attractive than non-athletes (Schulte-Hostedde et al. 2008, 2012) and that athletes report having more sexual partners (Faurie et al. 2004).

Possible fitness signaling of athletes is difficult to parse out because many people engage in physical activities who are not ICAs, from weekend games of Ultimate Frisbee or golf to intramural (i.e., club) sports to daily gym workouts. Furthermore, not all intercollegiate athletic programs are created equal, as some may be highly competitive while it is *relatively* easy to be a walk-on for others. Some studies have even found team-sport athletes (e.g., soccer) more attractive than individualized sports athletes (e.g., cross-country) (Schulte-Hostedde et al. 2008), though replication results have varied (Schulte-Hostedde et al. 2012). However, ICAs, especially those who have "lettered" or received a cloth school initial to wear as an insignia of achievement, are generally considered the best of best. Koziel et al. (2010) suggest that tattoos may enhance signals of physical quality, such as low fluctuating asymmetry (i.e., high bilateral symmetry), so it follows that ICAs may increase their competitive edge or signal status through body modifications. Hence, *we predict that ICAs will be tattooed and pierced at higher rates than other undergraduates to highlight or draw attention to their physiques and fitness.*

Prediction 2 Athletic teams resemble tribal groups in some ritualized war behaviors (e.g., Maori *haka*) and in their use of visual symbols (and often adopt names of native groups to evoke these) for group identification. These may be as important in distinguishing friend from foe in a chaotic skirmish or competition as they are as markers of status (Lynn and Medeiros 2017; Winegard and Deaner 2010). Furthermore, they may render the wearer ferocious, as Darwin (1997 [1839]) noted of the Maori *tā moko*. College- and sports-related tattoos may also serve as "pride-displays." Pride is one of the affective mechanisms that motivate status-seeking behavior and a fitness-relevant feature of human sociality (Cheng et al. 2010). Therefore, *we predict that ICAs will be more likely than other students to specifically signal their membership on teams through college- or sports-related tattoos, especially if the team or university carries prestige.*

Prediction 3 The exercise entailed in athletics generally leads to better overall health relative to non-athletes. A study of 5398 living alumnae found that former college athletes had a significantly lower risk of some cancers than non-athletes (Frisch et al. 1985). Studies find athletes display more efficient brain function than sedentary subjects in verbal memory and reaction time tests (Zhao et al. 2016). Regular exercise has long-term benefits in reducing susceptibility to infectious and non-communicable diseases, delays the aging of the immune system, and, most relevant to the present study, increases responses to bacterial and viral antigens immediately following exercise (Campbell and Turner 2018). Thus, *we predict that ICAs will report fewer tattoo- or piercing-related medical complications because athletes are generally healthier than other undergraduates.*

Study 1: Methods

Materials

We conducted two studies using the Body Art Study Questionnaire (BASQ) (Mayers et al. 2002). BASQ is a ten-item survey comprising single-item queries about tattooing (e.g., "Do you have or have you ever had any body tattoos?"), piercing (e.g., "Do you have or have you ever had any body piercings?"), associated medical complications (e.g., "If you now have or have ever had a tattoo/body piercing, have you suffered any medical complications?"), and removal of tattooing and piercing among US undergraduates (e.g., "Indicate the area from which a tattoo/piercing has been removed."), including an item to determine if respondents are ICAs in specific sports ("Are you an intercollegiate athlete?"). All items are answered with dichotomous yes/no responses. The survey was piloted and administered to a sample of US undergraduates (Mayers et al. 2002) and retested via the same recruiting techniques and university 5 years later (Mayers and Chiffriller 2008). Results of the two surveys were similar and consistent with other studies of body art prevalence among US undergraduates (Mayers and Chiffriller 2008), suggesting the BASQ is a reliable and valid instrument for the stated purpose. We also added items querying college or university and about tattoos related to one's college/university or a professional sports team.

We used Qualtrics online survey software (Provo, UT) to administer the survey nationally using convenience sampling with the snowball method via social media and email. Protocols were approved by the University of Alabama Institutional Review Board (#16-OR-007).

Participants

The survey was completed by 821 respondents, but 297 were removed due to inaccurate or incomplete responses. The final sample included 524 (77%) women, 153 men (22%), and 7 non-binary genders (1%) aged 18–57 (mean ± SD = 21.3 ± 4.03). Mean (± SD) BMI was 24.7 (± 5.30) with 5% categorized as underweight, 50% as normal/healthy, 19% as overweight, and 13% as obese. Respondents were from 78 different colleges or universities from all nine US census regions. Over half (59%) were from the East South Central and South Atlantic regions, suggesting that sampling was most successful in the authors' home region despite national recruitment. There were 33 (4.1%) ICAs in the sample (71% women; aged 18–39, mean ± SD = 21.3 ± 4.15). Mean BMI for these athletes was 23.8 ± 3.85.

Analysis

We downloaded survey data to IBM SPSS version 25 (Armonk, NY) and reversed items so 0 = no and 1 = yes. We determined descriptive statistics (mean ± SD) for demographic data and frequency (%) for other items. We calculated BMI (mean ± SD = 25 ± 5.70) using ((weight (lbs)/[height (in)]^2) × 703) and determined the frequencies of respondents having an underweight BMI (≤ 18.5), in the healthy/normal range (18.5–24.9), overweight (25.0–29.9), and obese (≥ 30.0), according to Centers for Disease Control and Prevention (CDC 2017) standards. We used chi-square (χ^2) and Fisher's exact tests to examine tattooing/piercing status with regard to gender, age, class standing, related medical complications, and ICA status. We conducted separate binary logistic regressions on tattooing, piercing, and related medical complications to test the hypothesis that body modifications signal fitness. Intercollegiate athlete status was the independent variable, with gender, age, class standing, BMI, and US region as control variables. Values were considered significant if $p < .05$. We tested for interaction effects by standardizing associated independent and dependent variables and covariates and creating cross-product variables, but there were no significant interactions in study 1 so are not reported further.

Results

Piercings were significantly more common than tattoos in the sample (Table 1), and tattoos and piercings were more common among women than men or other genders ($p < .001$). There were no differences for tattoos or piercings by age, but undergraduate seniors and juniors were most likely to be tattooed and pierced, respectively ($p < .001$).

To test prediction 1, that ICAs would be tattooed and pierced at higher rates than other undergraduates, we compared them using χ^2. There were no differences regarding tattooing, piercing, removals, or related medical complications. To test a possible relationship to fitness, we used binary logistic regression to examine the relationship of tattooing and piercing in ICAs with regard to BMI (Table 2). We regressed on tattoo status (0 = not tattooed, 1 = tattooed), with ICA status (0 = non-ICA, 1 = ICA), gender (1 = woman, 2 = man, 3 = non-binary), age, class standing (1 = freshman, 2 = sophomore, 3 = junior, 4 = senior, 5 = fifth year+), BMI, and US region (1 = Pacific, 2 = Mountain, 3 = West North Central, 4 = East North Central, 5 = Middle Atlantic, 6 = New England, 7 = West South Central, 8 = East South Central, 9 = South Atlantic) as covariates. This model was statistically significant ($\chi^2 = 84.859$, $p < .01$, $r^2 = .12$). Gender, class standing, and BMI were significant predictors, indicating that upper-class undergraduate women with greater BMI were more likely to be tattooed. However, there was no relationship for ICA status. Chi-square analysis of tattooing by BMI quartiles indicates lower rates of tattooing than expected for underweight and normal BMI respondents and higher than expected for overweight and obese respondents ($p < .001$). We conducted secondary regression on ICAs alone, including

Table 1 Distribution and associations of tattoos, piercings, and related medical complications

		Total % (*n*), 100% (684)	Tattooed, 38% (258)	Pierced, 56% (384)[a]**	Tattoo-related medical complication, 1% (4)	Piercing-related medical complication, 15% (99)**
Gender	Women	77% (524)	83% (215)**	93% (355)**	50% (2)	94% (93)**
	Men	22% (153)	15% (38)	6% (24)	25% (1)	5% (5)
	Non-binary	1% (7)	2% (5)	1% (5)	25% (1)	1% (1)
Class standing	Freshmen	22% (147)	16% (40)	22% (83)	0	18% (18)
	Sophomore	24% (167)	17% (43)	18% (76)	0	11% (11)
	Junior	24% (164)	24% (61)	26% (98)**	50% (2)	22% (22)
	Senior	22% (148)	30% (78)**	23% (88)	50% (2)	33% (33)
	Fifth year	8% (51)	13% (33)	9% (35)	0	13% (13)
Intercollegiate athletes		5% (33)	3% (8)	4% (16)	0	2% (2)

[a] Not including earlobes for women, per Mayers et al. (2002)

*$p < .05$; **$p < .01$

gender, age, class standing, and BMI as a quartiles variable, to determine if fitness played any role for tattooing in athletes, but BMI was not a significant predictor.

The regression model for the full sample on piercing (0 = not pierced, 1 = pierced) was also significant ($\chi^2 = 145.433$, $p < .01$, $r^2 = .19$), but gender was the only significant predictor, indicating that women were more likely to be pierced (Table 2).

Prediction 2, that ICAs would be more likely to get college-related tattoos, was not testable in this sample, as there were only a few respondents who had college-related tattoos ($n = 6$), none with pro sports tattoos, and no differences by gender or athlete status.

Prediction 3, that tattooed and pierced ICAs would have lower rates of related medical complications, was only partially testable with logistic regression because of the limited number of respondents with tattoo-related complications. The model for piercing complications included tattooing and piercing as additional covariates to determine if getting a tattoo or piercing increased risk of infection independent of other health-related factors (0 = no complications, 1 = complications). As Table 2 indicates, regression on piercing-related medical complications was significant ($\chi^2 = 31.645$, $p < .01$), but the amount of variation explained was small ($r^2 = .05$). Class standing was the only significant predictor, suggesting that complications were more common with age.

Table 2 Coefficients of logistic regressions on being tattooed, pierced, and tattoo- and piercing-related medical complications

	Tattooed***	Pierced***	Piercing complications**
Age	.039	.228	− .124
Class standing	.466***	.109	.269*
BMI	.333***	.038	.155
US region	.286*	.212	.004
Gender	.363***	1.045***	.177
ICA status	.111	.036	.308
Tattooed			.227
Pierced			− 11.415
Constant	− .607***	.197*	8.751

*$p < .05$, **$p < .01$, ***$p < .001$

Discussion

We tested the predictions consistent with the human canvas hypothesis that ICAs would draw attention to their group affiliations by tattooing and piercing at a higher rate than other undergraduates and be more likely to get tattoos related to their teams or university. Only one of these predictions was testable in this sample, as there were few cases of college- or sports-related tattoos. However, as there was no indication that ICAs were tattooed or pierced at higher rates than other undergraduates, there was no support for the human canvas hypothesis. We tested the upping the ante hypothesis via the prediction that athletes would have generally lower rates of tattooing or piercing complications. There was no statistical difference in medical complications between these groups. However, the number of tattoo-related medical complications was too low to reliably test with logistic regression.

Both hypotheses were falsified with regard to piercing. Relationships with piercing suggest that it is largely a gendered practice—people may collect more piercings with age when they are college-aged adults—and that piercings are susceptible to infections regardless of underlying health.

Study 2: Methods

Procedures and Materials

Because the number ICAs in study 1 was small, we repeated the protocol exclusively at the University of Alabama (UA), which has a large intercollegiate athletics program. Nearly half of UA's students are regional locals who have grown up in an era of repeated national championships in football and other sports, which inspires many university-related tattoos (Lynn and Medeiros 2017). For instance, in just the past 10 years, UA has won nationally in football five times, three times in golf, twice in gymnastics, and once in softball.

To ensure that the elicitation of ICA responses was random, we obtained email addresses for nearly all 31,514 undergraduates enrolled at UA (82% of enrollment in fall 2017) through a data request to the UA registrar and emailed the undergraduates directly using the Qualtrics survey software. No compensation or incentives were provided, so to increase the response rate, we set up Qualtrics to automatically resend the survey 3 days and 7 days later to students who had not previously responded. Nonetheless, the survey was anonymous, as URL information was not collected, and all protocols were approved by the UA Institutional Review Board (#16-OR-007-R2).

We used the same BASQ survey (Mayers et al. 2002) as study 1 with a few changes. We removed a caveat from the original survey that excluded earlobe piercings for women from the data collected. We believe this was a relic in the Mayers studies (Mayers et al. 2002; Mayers and Chiffriller 2008) related to the commonness of female earlobe piercings and the relative rarity of male earlobe piercings but that not including female earlobe piercings in our survey might cause medical complications in earlobes to be confused or underreported.

Participants and Analysis

The survey was started by 6537 respondents. We excluded 537 because they did not consent or did not complete the survey appropriately. The final sample included 4173 women and 1767 men, aged 18–62 (mean ± SD = 20.4 ± 3.10). BMI mean (± SD) was 24.6 (± 5.70), with 4% of the sample categorized as underweight, 61% as healthy/normal, 23% as overweight, and 12% as obese. Intercollegiate athletes comprised 5% (286) of the sample (64% women; aged 18–34, mean ± SD = 20.2 ± 2.01), which is 50% of the total UA student-athlete population. Mean BMI for these athletes was 24.9 ± 12.36.

We followed study 1 procedures for the analysis. Significant interaction effects were graphed at ± 1 SD following Dawson (2014) to facilitate the interpretation.

Results

As Table 3 indicates, 36% of the sample was tattooed, while 94% were pierced. Women were significantly more likely to be tattooed or pierced than men ($p < .001$), and most of those with a piercing included ears (95%, including earlobes). Piercing-related complications were more common than tattoo-related ones and more likely to occur among women. There were statistically significant differences in tattooing and piercing by class standing, but these differences do not follow a clear pattern.

Six percent ($n = 92$) women, 7% (32) men, and 9% (1) non-binary gender respondents reported having college-related tattoos, while 1% (11) of women, 2% (11) of men, and 9% (1) of non-binary gender reported pro sports-related tattoos. These rates were significantly higher for men and non-binary gender and lower for women than expected by χ^2 analysis ($p < .001$). Among ICAs, 15% (16) had college-related tattoos, which was also significantly higher than expected ($p < .05$), but, when examined by sport, only baseball players ($p = .006$) were more likely than other undergraduates to signal their school affiliation through their tattoo. Rowers were significantly less likely to be tattooed than were other undergraduates (Table 4). There were no other significant differences for tattooing. Piercing was more likely among rowers and volleyball players than among other students, whereas baseball and football players and swimmers/divers were less likely to be pierced.

To test our prediction that ICAs were more likely to highlight their fitness with tattoos or piercings than other undergraduates (*prediction 1*), we conducted separate hierarchical logistic regressions on tattooing and piercing (Table 5). We

Table 3 Distribution and associations of tattoos, piercings, and related medical conditions. Percentages calculated by column

		Total % (n), 100% (6004)	Tattooed, 36% (2172)	Pierced, 66% (3932)	Tattoo-related complication, 4% (22)	Piercing-related complication, 7% (425)
Gender	Women	70% (4208)*	78% (1696)**	94% (3712)**	50% (11)**	97% (412)*
	Men	30% (1776)	22% (487)	5% (212)	50% (11)	3% (11)
	Non-binary	<1% (28)	<1% (12)	< 1% (13)	0	<1% (2)
College standing	Freshman	25% (1503)**	20% (441)**	25% (997)**	18% (4)	23% (99)
	Sophomore	24% (1440)	24% (512)	25% (979)**	41% (9)	25% (107)
	Junior	23% (1354)	25% (545)**	22% (863)	9% (2)	22% (95)
	Senior	22% (1330)	24% (526)	23% (915)	18% (4)	24% (100)
	Fifth year	6% (333)	7% (148)	5% (178)	14% (3)	6% (24)
Intercollegiate athletes		5% (286)	2% (110)	5% (175)	10% (2)	6% (24)

*$p < .05$, **$p < .01$, ***$p < .001$

Table 4 Distribution of tattooing, piercing, and related complications by intercollegiate sport and comparisons with non-tattooed/pierced/complication within each sport (χ^2, Fisher's exact). Percentages calculated by row

		Total (n = 286)	Tattooed, 39% (110)	Pierced, 61% (175)	Tattoo-related complication, 1% (1)	Piercing-related complication, 8% (24)
Women's only	Gymnastics	3	33% (1)	100% (3)	0	33% (1)
	Rowing	35	20% (7)*	86% (30)*	0	14% (5)
	Soccer	31	32% (10)	71% (22)	0	3% (1)
	Softball	9	44% (4)	89% (8)	0	0
	Volleyball	22	32% (7)	86% (19)*	0	9% (2)
Men's only	Baseball	14	50% (7)	14% (2)***	0	0
	Football	31	48% (15)	19% (6)***	0	3% (1)
Women's/men's	Basketball	23	52% (12)	57% (13)	4% (1)	9% (2)
	Cross country	22	18% (4)	50% (11)	0	5% (1)
	Golf	6	17% (1)	33% (2)	0	0
	Swimming/diving	26	54% (14)	39% (10)**	0	8% (2)
	Tennis	11	25% (3)	46% (5)	0	18% (2)
	Track and field	35	43% (15)	63% (22)	0	11% (4)

In accordance with Title IX regulations that women's and men's intercollegiate athletics receive parity in funding, UA has 21 intercollegiate teams; five programs only have women's teams. Men's football receives significantly more funding than other sports, so there are only two programs with men-only teams. Other programs have men's teams and women's teams (i.e., they are not co-ed). Swimming and diving are separate teams, though our survey unintentionally grouped them together

*$p < .05$, **$p < .01$, ***$p < .001$

used standardized variables to create a cross-product of ICA-by-gender to test for interaction effects. The model for tattooing was significant with main effects of age, class standing, gender, and BMI. There was no main effect for ICAs, but there was a significant ICA-by-gender interaction effect. The model for piercing was also significant with main effects for gender and BMI. We graphed the ICA-by-gender interaction on tattooing at ± 1 SD to determine the effect direction. As Fig. 1 shows, women were more likely than men to be tattooed in general; however, among men, ICAs were more likely to be tattooed than non-ICAs; and among women, non-ICAs were more likely to be tattooed than ICAs.

We used the same covariates and interaction variables relative to college- and pro sports-related tattoos to test our prediction that ICAs would be more likely than other undergraduates to advertise their affiliation with their teams or sports through such tattoos (*prediction 2*) (Table 6). The model for college-related tattoos was significant with main effects for age, class standing, and ICA status and an ICA-by-gender interaction effect. The model for having a pro sports-related tattoo was also significant with main effects of class standing, gender, and ICA status. Both models suggest upper-class ICA men were more likely to get both types of tattoos compared to other students. Graphing the interaction effect for the college-related tattoos model (Fig. 2) confirms this, showing that

Table 5 Logistic regressions on being tattooed or pierced by age, undergraduate class standing, BMI, gender, intercollegiate athlete (ICA) status, and ICA status-by-gender

	Tattooed***	Pierced**
Age	.124***	.037
Class standing	.119***	− .032
BMI	.125***	.138*
Gender	.283**	1.833***
ICA status	.055	.004
ICA status-*x*-gender	− .099**	− .046
Constant	− .576***	.821***

*$p < .05$, **$p < .01$, ***$p < .001$

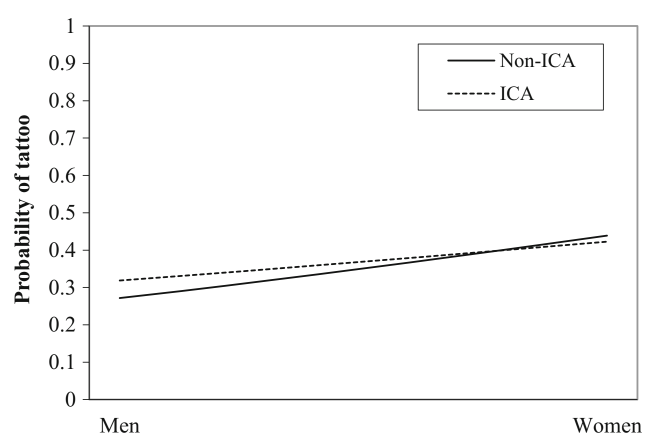

Fig. 1 Intercollegiate athlete status-by-gender interaction effect on being tattooed at ± 1 SD (two-way interaction with categorical moderator; http://www.jeremydawson.co.uk/slopes.htm)

Table 6 Logistic regressions on college- and pro sports-related tattoos by age, undergraduate class standing, BMI, gender, intercollegiate athletes (ICA) status, and ICA status-by-gender

	College-related tattoos***	Pro sports-related tattoos**
Age	− .256*	− .353
Class standing	.251*	.813**
BMI	.240**	.310
Gender	− .011	− .486*
ICA status	.176*	.346**
ICA status-*x*-gender	− .147*	.191
Constant	− 2.934***	− 5.040***

*$p < .05$, **$p < .01$, ***$p < .001$

among ICAs, men were more likely than women to get college-related tattoos.

We tested our prediction that ICAs would have lower rates of the tattoo- and piercing-related medical complications (*prediction 3*) using the same regression models as previous analyses, save including being tattooed or pierced as covariates (Table 7). The tattooing complications model was significant with a main BMI effect, while the piercing complications model was significant with a main gender effect. The majority (90%) of tattoo complications occurred among non-ICA respondents categorized as overweight or obese ($p = .007$). We conducted further analysis of tattoo complications and BMI to determine what body types had the greater effect. Chi-square of BMI quartiles and tattoo complications indicates that lower BMI respondents had significantly fewer and higher BMI had significantly more complications than expected ($p = .001$). Figure 3 illustrates these differences. Figure 3a shows the total respondents in each category who currently have or have ever had any tattoos, and Fig. 3b shows the subset of those who have suffered any related medical complications.

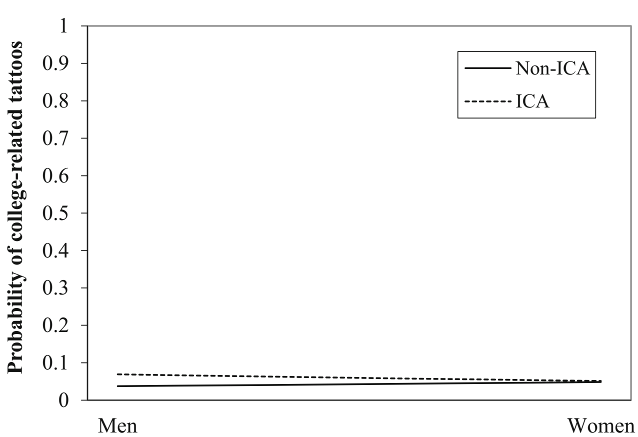

Fig. 2 Intercollegiate athlete status-by-gender interaction effect on college-related tattoos at ± 1 SD (two-way interaction with categorical moderator; http://www.jeremydawson.co.uk/slopes.htm)

Finally, we replaced ICA status (no/yes) in the models with specific sports to determine if, when controlling for other factors, respective athletes were more likely to be tattooed, pierced, or have relevant complications compared to other undergraduates. Only football ($p = .036$) and swimming/diving ($p = .028$) were significantly more likely to be tattooed, while rowers were less likely ($p = .023$). While football is a male-only sport, we compared male and female swimmers/divers and found the effect maintains for men only ($p = .039$). Basketball ($p = .041$) was positively associated with tattoo-related complications (it was the only sport with one athlete reporting a tattoo-related medical complication), while only tennis ($p = .038$) was significantly related to piercing complications.

Discussion

We conducted study 2 to obtain a larger sample of ICAs and retest our study predictions that athletes would advertise their fitness and college or sports affiliations with tattooing and piercing more than other undergraduates. Unlike study 1, there was support for both predictions for the human canvas hypothesis. We found a significant interaction effect indicating that, among men, athletes were more likely to be tattooed than non-athletes but that, among women, the opposite was true—non-athletes were the more likely to be tattooed. There was no main effect for being an ICA in general. Furthermore, we found significant effects for football players and swimmers/divers on tattooing. We can only speculate that the cultures of these sports are tattoo-positive, at least for men. Since tattooing and piercing rates in general populations tend to be more common among women than men (Laumann and Derick 2006; Mayers et al. 2002; Stirn et al. 2006), this emphasis for men stands out and may provide support for a social selection effect consistent with the human canvas hypothesis. In this sample, ICAs were more likely to advertise their college affiliation and favored pro sports teams through tattooing, particularly among men. Among sports, baseball players were most likely to bear college-related tattoos.

Additionally, we found a significant positive association between BMI and tattoos, as well as between BMI and tattoo complications. Piercing and BMI were also significantly positively associated, but BMI and piercing complications were not. There was no relationship with ICA status, so our third prediction was unsupported. However, as noted, the relationship among BMI, tattooing, and tattooing complications suggest the human canvas model may also be relevant to people with generally larger body types, though not necessarily athletes. BMI is a general indication of body classification but does not distinguish between body fat and muscle; thus, the categories for adult BMI may not apply to athletes (CDC 2017). The higher than expected rates of tattooing among overweight and obese body types suggest people may try to draw attention to muscular physiques or enhance their bodies

Table 7 Coefficients of binary logistic regressions on being tattooed, pierced, and tattoo- and piercing-related medical complications

	Tattoo complications[a]***	Piercing complications[a]**
Age	.091	.096
Class standing	− .086	.023
BMI	.552**	.039
Gender	− .106	.479**
ICA status	− 1.108	.051
Tattooed		.014
Pierced	.435	
ICA status-*x*-gender	2.586	.094
Constant	− 5.354	− 2.384***

[a] Tattooing and piercing excluded from respective models because of lack of variance

*$p < .05$, **$p < .01$, ***$p < .001$

in ways other than physique. However, consistent with costly honest signaling theory (Zahavi and Zahavi 1999), high BMI has health costs and can increase the risk of infection among those who are overweight or obese (Falagas and Kompoti 2006; Manna and Jain 2015; Martí et al. 2001). Thus, tattooing may enhance body appearance up to a certain point, beyond which it may draw attention to relatively poorer immune response.

General Discussion

We tested the human canvas and upping the ante hypotheses for tattooing and piercing as cultural patterns formed through evolutionary influences. The human canvas hypothesis suggests that the long tradition of tattooing throughout human history can be seen as conveying symbolic thought, individuality, or group affiliation. The upping the ante hypothesis pertains to the risks surrounding tattooing and body piercings (Carmen et al. 2012). Our predictions were that, as high fitness exemplars, intercollegiate athletes (ICAs) would (1) get tattooed and pierced at higher rates than other undergraduates to advertise their fitness (consciously or unconsciously), (2) get more college- or sports-related tattoos to indicate their affiliations or prestige (i.e., the human canvas hypothesis), and (3) have fewer tattoo- and piercing-related medical complications, highlighting their health (i.e., the upping the ante hypothesis).

Tattooing the Human Canvas

Consistent with other studies of tattooing and piercing prevalence among undergraduates and athletes, we found mixed results. In study 1, our findings mirrored those of Benjamins et al. (2006) and Mayers and Chiffriller (2008) in that ICAs as a group were no more likely than other undergraduates to get tattooed or pierced. However, in study 2, we found, similar to Mayers et al. (2002), that among men, athletes were more likely than non-athletes to be tattooed. This finding is consistent with sexual selection theory; Puts (2010) speculates, for instance, that female choice may drive alternative strategies to fighting ability as part of male contest competition. Kniffin and Palacio (2018) find that contact sports like football involve more "trash-talking" and "trolling," which are other alternative contest strategies. Tattoos, trash-talking, trolling, face painting, and mouth guards with teeth on them are all ways of looking fierce to "get in the heads" of the opposing players.

Football players in study 2 were more likely to be tattooed than other athletes, which may also be significant because UA's football team has the most prestige of any of its athletics. College football has been likened to a civil religion in the US South (Bain-Selbo 2009), and UA has dominated the sport on and off for decades, with 17 national championships in 75 years—five such titles in the past 9 years alone and final-four finishes in all but one of the other 4 years. Although football players did not report college or sports tattoos more than others, highlighting themselves with tattooing may nevertheless be part of individual "pride-displays" (Cheng et al. 2010). Winning athletes are frequently celebrated in media for their appearances as much as for their skills, including magazine spreads (e.g., *ESPN the Magazine*'s "Body Issues") and articles specifically about athlete tattoos (former Alabama football stars A.J. McCarron, Jesse Williams, and Reuben Foster were frequently noted in the press for their tattoos).

Winning contest competitions has been found to result in increases in testosterone and self-perceived mate value in males as well, leading them to engage in increased risk behavior (Longman et al. 2018). Numerous studies have linked tattooing with sensation-seeking and risk-taking (e.g., Carroll et al. 2002; King and Vidourek 2013; Roberts and Ryan 2002; Wohlrab et al. 2007). Pride is also associated with dominance and aggression (Cheng et al. 2010), in which female and male viewers attribute to tattooed males (Miłkowska et al. 2018; Wohlrab et al. 2009a). If sports invoke the coalitional psychology evolved for small-scale warfare (Deaner et al. 2012; Kruger et al. 2018; Winegard and Deaner 2010), football more closely resembles combat and invokes dominance than other sports (Pedersen and Cooke 2006; Reed 1913), and soldiers and sailors throughout history have worn tattoos to advertise their toughness (Govenar 2000; Parry 2006 [1933]; Steward 1990; Tuttle and Vale 1989).

On the other hand, college- and pro sports-related tattoos were more likely among ICAs than other undergraduates in study 2 and among UA baseball players more than other sports, despite the baseball team having a losing record. Though ironic, college-related tattoos among baseball players at UA may mean little more than it does in football players and

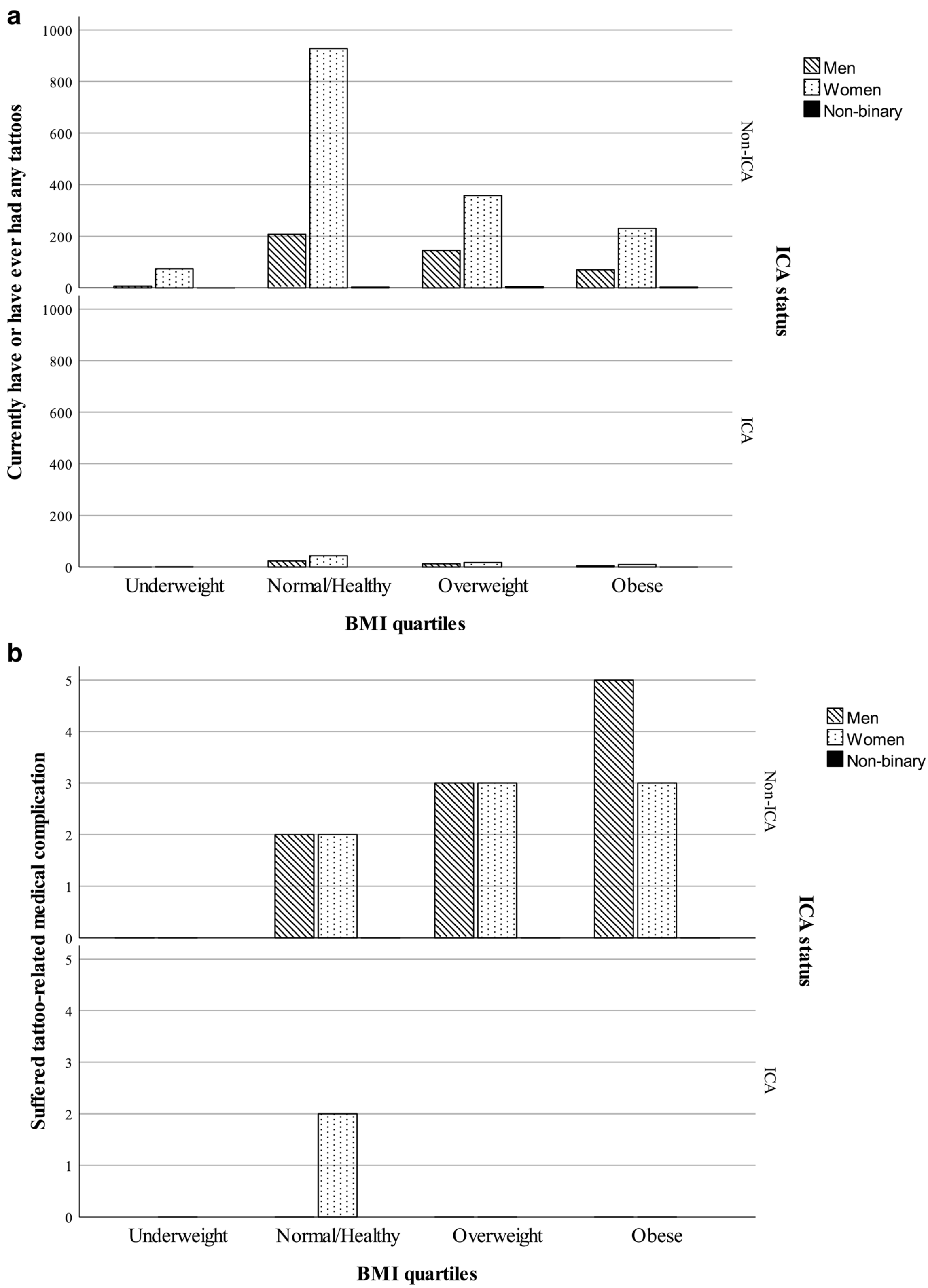

Fig. 3 Tattoos and tattoo-related medical complications by intercollegiate athlete (ICA) status, BMI category, and gender. The top row of each graph is non-IGA, and the bottom is ICA. **a** Sum of respondents who currently have or have ever had a tattoo. **b** Sum of respondents who have ever suffered a tattoo-related medical complication

male swimmers/divers, serving as an alternative contest strategy. In a study of future alliance formation among former combat adversaries, Barbaro et al. (2018) find that losers of agonistic encounters were generally interested in allying with winners. By contrast, winners were likely to ally with losers only if there were witnesses to the interaction, as a form of reputation management. College-related tattoos that are emblematic of someone else's success may force that interaction, serving as a surrogate to direct witnessing and represent an alliance with the winning person or, in this case, football team. For instance, we did not ask *unital when* they received their tattoos and know that some students get tattooed *before* becoming UA-affiliated athletes (for example, Reuben Foster infamously had an Auburn tattoo before committing to play for UA).

College- and sports-related tattoos may generally be more common among those wishing to advertise their affiliation with the pride of their community, as a by-product of warfare-selected coalitional psychology. For instance, our internet searches for college-related tattoos when giving presentations about this study indicate that there are numerous examples of college fan tattoos for schools with national championship teams, like Alabama, Auburn, or Clemson, whereas few (e.g., University of North Carolina Wilmington) to none (e.g., Southern Mississippi University) could be found for other schools. Winegard and Deaner (2010) find that sports fandom positively correlates with group-binding traits, such as loyalty, authority, and purity, particularly among males. We were surprised at the relatively low rate of college- and pro sports-related tattoos in study 1, given our non-random internet searches. By contrast, we did not expect the rate of pro sports-related tattoos to be so high in study 2, as Alabama has no professional athletic teams. However, in the past few years, the percentage of out-of-state students has increased. We did not query the content of those tattoos or the sports they related to but acknowledge that fan affiliations are not simply about pride-in-place. Sports loyalties can be inspired by family, peer group, aspirations, previous residence, legacy, performance, uniform colors, personality, or other types of loyalties (Bauer et al. 2008).

Upping the Ante Through Tattoos

We found an upping-the-ante effect irrespective of athlete status, which prevailed more in women, suggesting that tattooing may also be an alternative means of signaling health (Carmen et al. 2012; Wohlrab et al. 2009a) and not inherently tied to the coalitional psychology of team sports. The relationship among tattooing, BMI, and tattoo complications noted to some degree in both studies may relate to tattooing and piercing being redundant ways to draw attention to ICAs, who are already considered fit based on their athletic status. Tattooing may be an alternate means to signal fitness not just in the context of direct contest strategies but as an alternative signal to them (Lynn and Medeiros 2017). Not all fit individuals at universities are ICAs. Furthermore, body projects through tattooing and other use (cosmetics, clothing, etc.) can complement personality and the diverse factors that lend a person cultural capital—a form of power or influence through the manipulation and deployment of culturally salient symbols (Bourdieu 1986)—thus making them more attractive to those whose values are aligned. Consistent with the strategic pluralism theory (Gangestad and Simpson 2000), people vary in mating strategies depending on goals, current personal circumstances, and environmental conditions, among other factors.

The need to have signals to emphasize quality when conspicuous consumption is not possible may explain the widespread appearance of tattooing among lower socioeconomic groups, where tattooing is consistently associated with being “at-risk” for negative life consequences (e.g., Laumann and Derick 2006). The association between tattooing and negative risk appears to be largely part of a constellation of associated traits related to fast life history strategies (Del Giudice et al. 2015; Promislow and Harvey 1990). Where wealth may be lacking, conspicuous consumption is difficult (Sundie et al. 2011). Tattooing practices, on the other hand, enable individuals to invest relatively small amounts of money periodically and demonstrate fitness by healing well from injuries and drawing attention to their bodies. Piercing was not associated with fitness factors but appears to be primarily gendered behavior, consistent with other studies (e.g., Laumann and Derick 2006).

Our finding that tattoos up the ante where other signs of fitness may not be obvious puts several studies of the signaling functions of tattooing into context. Ludvico and Kurland's (1995) prediction that tattooing would occur at higher rates where pathogenicity was a greater threat as a way of drawing attention to fitness was not supported in a study of the ethnologic record. Instead, they found tattooing predicted by sexual selection independent of pathogenicity, suggesting a social selection effect. Koziel et al. (2010) found tattooing but not piercing positively correlated with bilateral symmetry, a well-established sign of developmental fitness. Research by Lynn et al. (2016) found that tattooing positively associated with an immunological priming effect when controlling for body density. While in the current study we found an association between high BMI and an increased chance of complications from tattooing, this finding might suggest that individual BMI is directly related to the probability of receiving tattoo complications.

However, tattooing appears to be a graded signal, given overall low rates of related medical complications in our studies and others (Mayers et al. 2002; Mayers and Chiffriller 2008), especially relative to piercing complications, which has much higher associated complication rates. Ninety-eight percent of people with overweight or obese phenotypes in both of our studies had no tattoo complications. The literature on BMI consistently indicates that normative standards are based on narrow ranges of body types, underrepresenting human diversity (Long et al. 1998). There is also a considerable literature on metabolically healthy obesity, and it is unclear what factors contribute to negative risks and which ones may be protective (Phillips 2013). Alternatively, the relationship between BMI and tattoo complications could reflect the association between low socioeconomic status and high BMI in developed countries, particularly for women (McLaren 2007). While college students overall represent a privileged class, individuals within this group with lower socioeconomic status may have relatively poorer health, consistent with general patterns (Marmot and Wilkinson 2005), and be more susceptible to complications from tattoos and piercing. This is supported by a positive bivariate correlation between tattoo- and piercing-related complications in study 1 ($p < .01$) and partial correlation when controlling for BMI in study 2 ($p < .04$). Future research that assesses socioeconomic status is needed to clarify this observed relationship.

It is also worth noting that the generally higher rates of tattooing among women in the current studies contrast with some other ideas about the signaling function of tattooing. For instance, Koziel et al. (2010) and Wohlrab et al. (2009a) suggest that tattoos may be an indicator of heightened masculinity, which is reported to increase the attractiveness of men only. However, in our studies, women reported much higher prevalence of tattooing (85% in study 1 and 78% in study 2) compared to men (15% in study 1 and 22% in study 2). These results indicate that future research should delve further into the varying cues of attractiveness that are being conveyed through tattooing, regardless of gender, as well as the plurality of taste among raters and changes in taste across rater lifespans (Morgan 2013).

Limitations

While our findings support evolutionary theories of tattooing, these data should be viewed cautiously with respect to several caveats. We used a short survey that takes minimal time to complete to increase compliance and ensure large samples. However, this format limited the amount and type of data we could collect and our ability to analyze factors that may influence tattooing, piercing, and complications, such as tattooing and piercing size or extent, body fat, sanitation and hygiene conditions, socioeconomic status, substance use, physical activity, and other health indicators. Healing of tattoos may result in trade-offs with other biological systems that we also did not collect data on. Furthermore, we did not analyze locations of tattoos on the body, so the communicative functions of tattoos may be more limited than our findings suggest. Other US tattoo studies (Horne et al. 2007; Sanders and Vail 2008) have found, for instance, that men are more likely than women to receive tattoos on arms and other publicly visible locations to advertise group affiliations; meanwhile, women are more likely than men to focus on personal enhancement and get tattoos on areas considered private and only shown under special circumstances. Nevertheless, when such tattoos are shown (e.g., one participant later revealed a "Roll Tide" tattoo to us on the inside of her lower lip), they still convey group pride and affiliation.

Finally, we used a convenience approach and sampled college students, so we can only generalize to an educated elite subset of the public (Henrich et al. 2010). Tattooing may actually be a more important signal among those less educated since education is also an alternate signal of quality (Spence 1973). Undergraduate students are a large demographic in the USA, but they are less "at-risk" than those without college educations or the means to enter college. We would therefore also predict that tattooing may be less common among graduate students or people with advanced degrees relative to undergraduates because these degrees serve as signals of fitness. People use a cross-section of communicative signals in their lives, some of which are complementary, such as athletes getting tattoos to symbolize their winning team; others may signal multiple psychosocial domains. For instance, fraternity/sorority, military, and religious affiliations are also popular tattoos. It may still be that fans are likely to get a sports tattoo, since their affiliation is not already self-evident, while athletes may be likely to broadcast other aspects of their lives (Lynn and Medeiros 2017), factors that our survey approach did not account for. Alternatively, it may be that while tattoos are generally used to signal health in a general population, football players and male swimmers and divers get them at higher rates because of subcultural or fandom-associated factors within or around those sports.

Conclusion

Our analyses of undergraduate samples suggest that, depending on the context, tattooing may signal fitness and affiliations or play a role as complementary to or where other signals of fitness are not being used. We found that men in intercollegiate sports are more likely than other students to be tattooed and that intercollegiate athletes are more likely to bear college and pro sports-related tattoos, which support the human canvas hypothesis of tattooing. There was support as well for the upping of the ante hypothesis of tattooing among undergraduates in general, but not athletes per se. Our data suggest a costly honest signaling effect because there appears to be a benefit for fit phenotypes of tattooing but a higher rate of tattoo-related infection for those who are less healthy. Further research into the evolutionary science of body use might reveal the multiple ways in which fitness can be displayed and how culture and biology have interacted throughout our evolutionary history.

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References

Bain-Selbo, E. (2009). From lost cause to third-and-long: college football and the civil religion of the south. Journal of Southern Religion, 11.

Barbaro, N., Mogilski, J. K., Shackelford, T. K., & Pham, M. N. (2018). Men's interest in allying with a previous combatant for future group combat. *Human Nature, 29*(3), 328–336.

Bauer, H. H., Stokburger-Sauer, N. E., & Exler, S. (2008). Brand image and fan loyalty in professional team sport: a refined model and empirical assessment. *Journal of Sport Management, 22*(2), 205–226.

Benjamins, L. J., Risser, W. L., Cromwell, P. F., Feldmann, J., Bortot, A. T., Eissa, M. A., & Nguyen, A. B. (2006). Body art among minority high school athletes: prevalence, interest and satisfaction; parental knowledge and consent. *Journal of Adolescent Health, 39*(6), 933–935. https://doi.org/10.1016/j.jadohealth.2006.06.012.

Bourdieu, P. (1986). The forms of capital. In J. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241–258). New York: Greenwood.

Bulbulia, J. (2008). Free love: religious solidarity on the cheap. In J. Bulbulia, R. Sosis, E. Harris, R. Genet, C. Genet, & K. Wyman (Eds.), *The evolution of religion: Studies, theories, and critiques* (pp. 153–160). Santa Margarita, CA: Collins Foundation Press.

Campbell, J. P., & Turner, J. E. (2018). Debunking the myth of exercise-induced immune suppression: redefining the impact of exercise on immunological health across the lifespan. *Frontiers in Immunology, 9*(Article 648), 648. https://doi.org/10.3389/fimmu.2018.00648.

Carmen, R. A., Guitar, A. E., & Dillon, H. M. (2012). Ultimate answers to proximate questions: the evolutionary motivations behind tattoos and body piercings in popular culture. *Review of General Psychology, 16*(2), 134–143. https://doi.org/10.1037/a0027908.

Carroll, S. T., Riffenburgh, R. H., Roberts, T. A., & Myhre, E. B. (2002). Tattoos and body piercings as indicators of adolescent risk-taking behaviors. *Pediatrics, 109*(6), 1021–1027. https://doi.org/10.1542/peds.109.6.1021.

Centers for Disease Control and Prevention. (2017). *About adult BMI.* Retrieved June 13, 2018, from https://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html

Cheng, J. T., Tracy, J. L., & Henrich, J. (2010). Pride, personality, and the evolutionary foundations of human social status. *Evolution and Human Behavior, 31*(5), 334–347. https://doi.org/10.1016/j.evolhumbehav.2010.02.004.

Darwin, C. (1997 [1839]). *The voyage of the beagle*. Hertfordshire: Wordsworth Editions.

Dawson, J. F. (2014). Moderation in management research: What, why, when, and how. *Journal of Business and Psychology, 29*(1), 1–19.

De Block, A., & Dewitte, S. (2009). Darwinism and the cultural evolution of sports. *Perspectives in Biology and Medicine, 52*(1), 1–16.

Deaner, R. O., Geary, D. C., Puts, D. A., Ham, S. A., Kruger, J., Fles, E., Winegard, B., & Grandis, T. (2012). A sex difference in the predisposition for physical competition: males play sports much more than females even in the contemporary US. *PLoS One, 7*(11), e49168.

Del Giudice, M., Gangestad, S. W., & Kaplan, H. S. (2015). Life history theory and evolutionary psychology. In D. M. Buss (Ed.), *The handbook of evolutionary psychology* (pp. 88–114) doi:https://doi.org/10.1002/9781119125563.evpsych102.

DeMello, M. (2000). *Bodies of inscription: a cultural history of the modern tattoo community.* Durham, NC: Duke University Press.

DeMello, M. (2007). *Encyclopedia of body adornment*. Westport, CT: Greenwood Press.

Deter-Wolf, A., Robitaille, B., Krutak, L., & Galliot, S. (2016). The world's oldest tattoos. *Journal of Archaeological Science: Reports, 5*, 19–24. https://doi.org/10.1016/j.jasrep.2015.11.007.

Edgerton, R. B., & Dingman, H. F. (1963). Tattooing and identity. *International Journal of Social Psychiatry, 9*(2), 143–153. https://doi.org/10.1177/002076406300900211.

Falagas, M. E., & Kompoti, M. (2006). Obesity and infection. *The Lancet Infectious Diseases, 6*(7), 438–446.

Faurie, C., Pontier, D., & Raymond, M. (2004). Student athletes claim to have more sexual partners than other students. *Evolution and Human Behavior, 25*(1), 1–8.

Forbes, G. B. (2001). College students with tattoos and piercings: motives, family experiences, personality factors, and perception by others. *Psychological Reports, 89*(3), 774–786. https://doi.org/10.2466/pr0.2001.89.3.774.

Frisch, R. E., Wyshak, G., Albright, N., Albright, T., Schiff, I., Jones, K., Witschi, J., Shiang, E., Koff, E., & Marguglio, M. (1985). Lower prevalence of breast cancer and cancers of the reproductive system among former college athletes compared to non-athletes. *British Journal of Cancer, 52*(6), 885–891.

Gangestad, S. W., & Simpson, J. A. (2000). The evolution of human mating: trade-offs and strategic pluralism. *Behavioral and Brain Sciences, 23*(0140–525; 4), 573–587.

Gilbert, S. (2000). Tattoo history: a source book: an anthology of historical records of tattooing throughout the world. In *New York*. Berkeley, CA: Juno Books.

Govenar, A. (2000). The changing image of tattooing in American culture, 1846–1966. In J. Caplan (Ed.), *Written on the body: the tattoo in European and American history* (pp. 212–233). Princeton: Princeton University Press.

Grafen, A. (1991). Modelling in behavioural ecology. In J. R. Krebs & N. B. Davies (Eds.), *Behavioural ecology: an evolutionary approach* (3rd ed., pp. 5–31). Hoboken, NJ: Blackwell Science.

Hambly, W. D. (2009 [1925]). *The history of tattooing*. Mineola, NY: Dover.

Hawkes, K., & Bliege Bird, R. (2002). Showing off, handicap signaling, and the evolution of men's work. *Evolutionary Anthropology: Issues, News, and Reviews, 11*(2), 58–67.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences, 33*(2–3), 61–83. https://doi.org/10.1017/S0140525X0999152X.

Horne, J., Knox, D., Zusman, J., & Zusman, M. E. (2007). Tattoos and piercings: attitudes, behaviors, and interpretations of college students. *College Student Journal, 41*(4), 1011–1020.

King, K. A., & Vidourek, R. A. (2013). Getting inked: tattoo and risky behavioral involvement among university students. *Social Science Journal, 50*(4), 540–546. https://doi.org/10.1016/j.soscij.2013.09.009.

Kluger, N. (2015). Epidemiology of tattoos in industrialized countries. *Current Problems in Dermatology, 48*, 6–20. https://doi.org/10.1159/000369175.

Kluger, N., Hubiche, T., & Del Giudice, P. (2013). Tattoo-induced edema of the lower limbs mimicking cellulitis: report of two cases. *International Journal of Dermatology, 52*(3), 384–386. https://doi.org/10.1111/j.1365-4632.2011.04901.x.

Kluger, N., & Koljonen, V. (2012). Tattoos, inks, and cancer. *The Lancet Oncology, 13*(4), e161–e168. https://doi.org/10.1016/S1470-2045(11)70340-0.

Kniffin, K. M., & Palacio, D. (2018). Trash-talking and trolling. *Human Nature, 29*(3), 211–218.

Kniffin, K. M., & Sugiyama, M. S. (2018). Toward a natural history of team sports. *Human Nature, 29*(3), 353–369.

Kohler, W. (1925). *The mentality of apes (E. Winter Trans.)*. New York: Routledge.

Koziel, S., Kretschmer, W., & Pawlowski, B. (2010). Tattoo and piercing as signals of biological quality. *Evolution and Human Behavior, 31*(3), 187–192. https://doi.org/10.1016/j.evolhumbehav.2009.09.009.

Kruger, D. J., Falbo, M., Blanchard, S., Cole, E., Gazoul, C., Nader, N., & Murphy, S. (2018). University sports rivalries provide insights on coalitional psychology. *Human Nature, 29*(3), 337–352.

Krutak, L. (1999). St. Lawrence island joint-tattooing: spiritual/medicinal functions and inter-continental possibilities. *Études/Inuit/Studies, 23*(1–2), 229–252.

Krutak, L. (2007). *The tattooing arts of tribal women*. London: Desert Hearts.

Kurzban, R., & Leary, M. R. (2001). Evolutionary origins of stigmatization: the functions of social exclusion. *Psychological Bulletin, 127*(2), 187–208.

Laumann, A. E., & Derick, A. J. (2006). Tattoos and body piercings in the United States: a national data set. *Journal of the American Academy of Dermatology, 55*(3), 413–421.

Laux, P., Tralau, T., Tentschert, J., Blume, A., Al Dahouk, S., Bäumler, W., Bernstein, E., Bocca, B., Alimonti, A., & Colebrook, H. (2015). A medical-toxicological view of tattooing. *The Lancet, 10016*(23–29), 395–402. https://doi.org/10.1016/S0140-6736(15)60215-X.

Lombardo, M. P. (2012). On the evolution of sport. *Evolutionary Psychology, 10*(1), 147470491201000101.

Long, A., Prewitt, T., Kaufman, J., Rotimi, C., Cooper, R., & McGee, D. (1998). Weight–height relationships among eight populations of West African origin: the case against constant BMI standards. *International Journal of Obesity, 22*(9), 842–846.

Longman, D. P., Surbey, M. K., Stock, J. T., & Wells, J. C. (2018). Tandem androgenic and psychological shifts in male reproductive effort following a manipulated "win" or "loss" in a sporting competition. *Human Nature, 29*(3), 283–310.

Ludvico, L. R., & Kurland, J. A. (1995). Symbolic or not-so-symbolic wounds: the behavioral ecology of human scarification. *Ethology and Sociobiology, 16*(2), 155–172. https://doi.org/10.1016/0162-3095(94)00075-I.

Lynn, C. D., & Medeiros, C. A. (2017). Tattooing commitment, quality, and football in southeastern North America. In C. D. Lynn, A. L. Glaze, W. A. Evans, & L. K. Reed (Eds.), *Evolution education in the American south* (pp. 263–280). New York: Palgrave Macmillan.

Lynn, C. D., Dominguez, J. T., & Decaro, J. A. (2016). Tattooing to "toughen up": tattoo experience and secretory immunoglobulin a. *American Journal of Human Biology, 28*, 603–609. https://doi.org/10.1002/ajhb.22847.

MacKinnon, J. R. (1978). *The ape within us*. New York: Holt, Rinehart and Winston.

Manna, P., & Jain, S. K. (2015). Obesity, oxidative stress, adipose tissue dysfunction, and the associated health risks: causes and therapeutic strategies. *Metabolic Syndrome and Related Disorders, 13*(10), 423–444.

Manuel, L., & Sheehan, E. (2007). Getting inked: tattoos and college students. *College Student Journal, 41*, 1089–1097.

Marmot, M., & Wilkinson, R. (2005). *Social determinants of health*. Oxford: Oxford University Press.

Martí, A., Marcos, A., & Martínez, J. A. (2001). Obesity and immune function relationships. *Obesity Reviews, 2*(2), 131–140. https://doi.org/10.1046/j.1467-789x.2001.00025.x.

Mayers, L. B., Judelson, D. A., Moriarty, B. W., & Rundell, K. W. (2002). Prevalence of body art (body piercing and tattooing) in university undergraduates and incidence of medical complications. *Mayo Clinic Proceedings, 77*(1), 29–34.

Mayers, L. B., & Chiffriller, S. H. (2008). Body art (body piercing and tattooing) among undergraduate university students: "then and now". *Journal of Adolescent Health, 42*(2), 201–203. https://doi.org/10.1016/j.jadohealth.2007.09.014.

McBrearty, S., & Brooks, A. S. (2000). The revolution that wasn't: a new interpretation of the origin of modern human behavior. *Journal of Human Evolution, 39*(5), 453–563.

McLaren, L. (2007). Socioeconomic status and obesity. *Epidemiologic Reviews, 29*(1), 29–48.

Miłkowska, K., Ziomkiewicz, A., & Galbarczyk, A. (2018). Tattooed man: could menstrual cycle phase and contraceptive use change female preferences towards bad boys? *Personality and Individual Differences, 121*(supplement C), 41–47. https://doi.org/10.1016/j.paid.2017.09.017.

Miller, G. (2001). *The mating mind: how sexual choice shaped the evolution of human nature*. New York: Anchor Books.

Morgan, E. M. (2013). Contemporary issues in sexual orientation and identity development in emerging adulthood. *Emerging Adulthood, 1*(1), 52–66.

Pabst, M. A., Letofsky-Papst, I., Bock, E., Moser, M., Dorfer, L., Egarter-Vigl, E., & Hofer, F. (2009). The tattoos of the Tyrolean iceman: a light microscopical, ultrastructural and element analytical study. *Journal of Archaeological Science, 36*(10), 2335–2341. https://doi.org/10.1016/j.jas.2009.06.016.

Parry, A. (2006 [1933]). *Tattoo: secrets of a strange art*. Mineola, NY: Dover.

Pedersen, H. K., & Cooke, N. J. (2006). From battle plans to football plays: extending military team cognition to football. *International Journal of Sport and Exercise Psychology, 4*(4), 422–446.

Phillips, C. M. (2013). Metabolically healthy obesity: definitions, determinants and clinical implications. *Reviews in Endocrine and Metabolic Disorders, 14*(3), 219–227.

Promislow, D. E., & Harvey, P. H. (1990). Living fast and dying young: a comparative analysis of life-history variation among mammals. *Journal of Zoology, 220*(3), 417–437.

Puts, D. A. (2010). Beauty and the beast: mechanisms of sexual selection in humans. *Evolution and Human Behavior, 31*(3), 157–175.

Reed, H. (1913). *Football for public and player*. New York: Frederick A. Stokes Company.

Resenhoeft, A., Villa, J., & Wiseman, D. (2008). Tattoos can harm perceptions: a study and suggestions. *Journal of American College Health, 56*(5), 593–596. https://doi.org/10.3200/JACH.56.5.593-596.

Rivers, W. H. R. (2001 [1923]). *Medicine, magic, and religion: the Fitzpatrick lectures delivered before the royal college of physicians of London in 1915 and 1916*. London: Routledge.

Roberts, T. A., & Ryan, S. A. (2002). Tattooing and high-risk behavior in adolescents. *Pediatrics, 110*(6), 1058–1063. https://doi.org/10.1542/peds.110.6.1058.

Roughgarden, J. (2009). *The genial gene: deconstructing Darwinian selfishness*. Berkeley: University of California.

Rush, J. A. (2005). *Spiritual tattoo: a cultural history of tattooing, piercing, scarification, branding, and implants*. Berkeley, CA: Frog.

Sanders, C., & Vail, D. A. (2008). *Customizing the body: the art and culture of tattooing*. Philadelphia: Temple University Press.

Schulte-Hostedde, A. I., Eys, M. A., Emond, M., & Buzdon, M. (2012). Sport participation influences perceptions of mate characteristics. *Evolutionary Psychology, 10*(1), 147470491201000.

Schulte-Hostedde, A. I., Eys, M. A., & Johnson, K. (2008). Female mate choice is influenced by male sport participation. *Evolutionary Psychology, 6*(1), 147470490800600.

Sosis, R. (2006). Religious behaviors, badges, and bans: signaling theory and the evolution of religion. In P. McNamara & J. H. Ellens (Eds.), *Where god and science meet: how brain and evolutionary studies alter our understanding of religion, volume 1: evolution, genes, and the religious brain* (pp. 61–86). Westport, CT: Praeger.

Sosis, R., Kress, H. C., & Boster, J. S. (2007). Scars for war: evaluating alternative signaling explanations for cross-cultural variance in ritual costs. *Evolution and Human Behavior, 28*(4), 234–247.

Spence, M. (1973). Job market signaling. *The Quarterly Journal of Economics, 87*(3), 355–374.

Steward, S. M. (1990). *Bad boys and tough tattoos: a social history of the tattoo with gangs, sailors, and street-corner punks 1950–1965*. Binghamton, NY: Harrington Park Press.

Stirn, A. (2007). "My body belongs to me"–cultural history and psychology of piercings and tattoos. ["Mein Korper gehort mir" -

Kulturgeschichte und Psychologie des Piercing und Tattoo] *Therapeutische Umschau. Revue Therapeutique, 64*(2), 115–119. https://doi.org/10.1024/0040-5930.64.2.115.

Stirn, A., Hinz, A., & Brahler, E. (2006). Prevalence of tattooing and body piercing in Germany and perception of health, mental disorders, and sensation seeking among tattooed and body-pierced individuals. *Journal of Psychosomatic Research, 60*(5), 531–534. https://doi.org/10.1016/j.jpsychores.2005.09.002.

Sugiyama, M. S., Mendoza, M., White, F., & Sugiyama, L. (2018). Coalitional play fighting and the evolution of coalitional intergroup aggression. *Human Nature, 29*(3), 219–244.

Sundie, J. M., Kenrick, D. T., Griskevicius, V., Tybur, J. M., Vohs, K. D., & Beal, D. J. (2011). Peacocks, Porsches, and Thorstein Veblen: conspicuous consumption as a sexual signaling system. *Journal of Personality and Social Psychology, 100*(4), 664–680.

Sweetman, P. (1999). Anchoring the (postmodern) self? Body modification, fashion and identity. *Body & Society, 5*(2–3), 51–76. https://doi.org/10.1177/1357034X99005002004.

Timming, A. R. (2017). Body art as branded labour: at the intersection of employee selection and relationship marketing. *Human Relations, 70*(9), 1041–1063.

Tuttle, L., & Vale, V. (1989). Interview with Lyle Tuttle. In V. Vale & A. Juno (Eds.), *Modern primitives: an investigation of contemporary adornment and ritual* (pp. 114–117). San Francisco: RE/Search.

Van Vugt, M. (2009). Sex differences in intergroup competition, aggression, and warfare: the male warrior hypothesis. *Annals of the New York Academy of Sciences, 1167*(1), 124–134.

Winegard, B., & Deaner, R. O. (2010). The evolutionary significance of red sox nation: sport fandom as a by-product of coalitional psychology. *Evolutionary Psychology: An International Journal of Evolutionary Approaches to Psychology and Behavior, 8*(3), 432–446.

Wohlrab, S., Fink, B., Kappeler, P. M., & Brewer, G. (2009a). Perception of human body modification. *Personality and Individual Differences, 46*(2), 202–206. https://doi.org/10.1016/j.paid.2008.09.031 .

Wohlrab, S., Fink, B., Kappeler, P. M., & Brewer, G. (2009b). Differences in personality attributions toward tattooed and nontattooed virtual human characters. *Journal of Individual Differences, 30*(1), 1–5.

Wohlrab, S., Stahl, J., Rammsayer, T., & Kappeler, P. M. (2007). Differences in personality characteristics between body-modified and non-modified individuals: associations with individual personality traits and their possible evolutionary implications. *European Journal of Personality, 21*(7), 931–951. https://doi.org/10.1002/per.642.

Zhao, E., Tranovich, M. J., DeAngelo, R., Kontos, A. P., & Wright, V. J. (2016). Chronic exercise preserves brain function in masters athletes when compared to sedentary counterparts. *The Physician and Sportsmedicine, 44*(1), 8–13.