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ORIGINAL ARTICLE

Gender Performance in the NCAA Rifle Championships: Where is the Gap?

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Abstract The current study aimed to compare shooting performance between male and female athletes during the National Collegiate Athletic Association (NCAA) Rifle Championship from the 2007 to 2013 seasons. This sport is distinct from most competitive sports as it requires little physical exertion, so physiological/ biomechanical differences between the genders that generally bring about superior performance by males relative to females may have only minimal effect on shooting performance. NCAA competitions, unlike Olympic shooting events today, allow male and female shooters to compete against each other. Using archival data covering a period of 7 years from both the team and individual tournaments, 555 scores of the best 149 shooters among mostly U.S. collegiate athletes (the best of whom went on to compete in the Olympics) were analyzed using a generalized estimating equation (GEE) model. We found no differences in performance between the genders both during team and individual competitions. The results suggest that Olympic shooting is exercising a "separate and (un)equal" policy which should be reconsidered.

Keywords Gender · Performance · Rifle shooting

> "I started out only knowing that men and women compete against each other. It wasn't until I learned shooting was an Olympic sport that I realized men and women didn't compete against each other."
>
> Jamie Gray, a 2008 Olympian in Rifle, (USA Shooting 2012, para. 3)

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Introduction

Most research focusing on the diminished performance of females relative to males under similar competitive conditions, otherwise known as the gender gap in sports, (e.g., Coast et al. 2004; Seiler et al. 2007; Tatem et al. 2004) explored international events that kept males and females competing apart. Very few sports in the Olympic Games allow for direct competition between the genders (e.g., equestrian, mixed-doubles in badminton and tennis) mainly due to physiological differences. Going beyond performance analysis, Anderson (2008) demonstrated in the U.S. that segregation of men into an exclusively male sport (i.e., American football) limited their social contact with women and enhanced orthodox, largely negative, views regarding women. However, when these same men competed in a gender-integrated sport (i.e., cheerleading), they positively modified their attitudes toward women.

The current study explored the performance of National Collegiate Athletic Association (NCAA) athletes in the U.S. and attempted to study gender differences in shooting performance by employing archival data from gender-mixed NCAA national competitions. This practice of women competing with men in the same competition stands in stark contrast to what is practiced in the Olympic Games today. Starting from the 1968 games women competed in Olympic shooting events (International Shooting Sport Federation, n.d.). At first, the competitions were mixed, but gender barriers started to emerge when Margaret Thompson Murdock became the first female to win a medal in a shooting event during the 1976 Olympics (Corbitt 2011). Eight years later, it was determined that most of the shooting events would be segregated (Sports Reference, n.d.). The only two competitions following that maintained gender integration were trap and skeet shooting.

The NCAA competition thus presents a unique opportunity to study gender performance in a direct competition environment. Since both events involve elite performers (and indeed the best NCAA shooters go on to compete in the Olympics), the collegiate event can serve as a testing ground to assess whether females are discriminated against when performing in the Olympic, gender-segregated shooting competitions or if the separation is justified since their performance when competing against males is indeed inferior.

Gender Differences in Sport

There is no dispute that men have superior physical attributes when it comes to sport performance which requires much physical exertion (Maldonado-Martin et al. 2004; Perez-Gomez et al. 2008; Sparling and Cureton 1983). With the onset of puberty, men tend to have considerably higher testosterone levels than women, which in turn affects their physiology (Ramos et al. 1998). As such, men generally have more muscle mass, greater height, higher aerobic and anaerobic capacities, and higher hemoglobin levels than women. Early on, in an extensive meta-analysis of gender differences in motor performance, Thomas and French (1985) unequivocally concluded that, "in any motor task for which size and strength are an advantage, adolescent boys will have a biological advantage in performance when compared with adolescent girls because boys are larger and have more muscle" (p. 261).

Aside from biological differences, environmental constraints may play a role across diverse countries. For example, Coakley and White (1992) found in Great Britain that women had limited access to superior facilities and Hoeber (2007), in Canada, found that they did not have similar access to elite coaching as men did. Similar treatment was possibly associated with lower motivation to participate in sport among U.S. females (Hines 2004). Other research has focused on psychological factors such as gender roles (Lynn et al. 2002) and stereotype threat (Chalabaev et al. 2008). For instance, Chalabaev et al. showed that French female athletes were slower to perform a soccer dribbling task when told the task was supposedly diagnostic of athletic ability (i.e., stereotype-threat condition), as opposed to when it was purportedly diagnostic of psychological factors. In the U.S., Stone and McWhinnie (2008) showed similar effects in golf-putting. Others (Croson and Gneezy 2009; Gneezy et al. 2003) suggested that there were differences in the competitive nature between the genders. For example, Gneezy and Rustichini (2004) showed that when 9-year old children in Israel ran alone, there was no difference in performance between boys and girls (as physiological differences are minimal before puberty). However, when subsequently competing against a closely matched peer, only boys improved their performance. The time improvement in the mixed group races was far greater for boys than it was for girls, and, in 73 % of these observations, boys who were slower than the girls when running alone prior won the mixed competition. The reverse was true only in 17 % of the observations. Similarly, using a point-by-point analysis of professional tennis players' performances in Grand Slam international tournaments, Paserman (2007) found that, relative to men, women were more likely to commit unforced errors at crucial stages of the match. Thus physiological, societal and psychological factors combine to disadvantage women in sport across various cultures.

Much research on the gender gap in sport has employed either non-athletes (e.g., Perez-Gomez et al. 2008; Stone and McWhinnie 2008) or non-elite athletes (e.g., Chalabaev et al. 2008; Sparling and Cureton 1983). Another line of research focused on the World and Olympic records, which allowed longitudinal comparison of gender performance in the international arena. Some (Tatem et al. 2004) have found that the gender gap was actually narrowing over time. Tracking the records obtained by Olympic champions in the 100 m sprint from 1900 through the 2004 games, the authors created two linear gender regression lines and, based on where the lines intersected, predicted that male and female runners should perform at a similar level in the 2156 Olympics and thereafter female runners would outperform their male counterparts. However, a later study by Seiler et al. (2007) rejected this projection. Employing a more comprehensive database composed of male and female finalists' times in the Olympics and World Championship finals for running, swimming, and speed skating from 1952 to 2006, they found that while the gender gap in performance was indeed decreasing from the 1950s to the 1980s, it has been increasing since. The authors argued that in the beginning of the second half of the 20th century, female athletes used testosterone extensively as a performance-enhancement substance since the drugs proved to be much more effective on them than on male athletes (Franke and Berendonk 1997). While acknowledging the potential effect of performance-enhancement substances, Thibault et al. (2010), who studied the top performances in five Olympic sports from as early as 1891 to 2008, suggested that the narrowing gap might also be attributed to multiple countries' greater investment in women's sports and women's increased access to training techniques, medical assistance, and nutrition that were once exclusive to men. Regardless of these other factors, Seiler et al. go on to argue that it was not until the early 1990s that anti-doping tests in elite competitions were fully capable to detect users; as a result, with presumably fewer female athletes doping for the fear of being caught, the growing gap since has reflected the true physiological differences between the genders. Like Seiler et al., Thibault et al. concluded that the current gender gaps may never narrow again. Similarly, Lepers and Maffiuletti (2011), who studied the performance of athletes in the Hawaii Ironman, documented a mean gender difference of 12.6 % since 1988 and predicted that gender differences in Ironman total performance was unlikely to change in the future. Lastly, Coast et al. (2004), who studied the world records as of December 2002 for male and female runners from 100 m to 200 km distances, found that male runners outperformed female runners at all distances and that the performance gap actually widened with greater distance.

Gender Differences in Rifle Shooting Performance

Rifle shooting is one sport where the physical demands placed on the athletes are relatively minor. Factors that affect rifle shooting performance include aiming, breathing, trigger control, position, and steadiness (Australian International High Power Association, n.d.). All of these factors involve lining up the shot and minimizing the amount of movement in all body parts when pulling the trigger to deliver an accurate shot. As such, Niinimaa and McAvoy (1983), using a Canadian sample, found that body sway was important for shooting performance. In Finland, Era et al. (1996) highlighted stability during the aiming period as well as gun barrel stability (Mononen et al. 2007). Lastly, Janelle et al. (2000) found in the U.S. that gaze behavior was different between expert shooters and novices.

Furthermore, shooters must take shots over an extended period of time, so they are trained to keep their muscles relaxed and to sustain their rifle position with skeletal support for steadiness. For the most part, physiological differences between the genders do not appear to affect any of these factors (Kemnitz et al. 1997).

Since most studies in the realm of rifle shooting focused on expertise (e.g., Konttinen et al. 1998 [Finland]; Mononen et al. 2007), they sought to reduce unrelated variability and, as such, often confined themselves to male-only samples. Moreover, much applied research is undertaken by security forces in male-only units (e.g., Chung et al. 2005 [U.S.]; Couture et al. 1999 [Canada]; Tharion et al. 2003 [U.S.]).

Among the few studies that did include women and analyzed gender effects, Kemnitz et al. (1997) found no gender difference in both marksmanship and steadiness among 13 female and 15 male U.S. participants using an army rifle simulator, even though the men in their sample had significantly less body fat, leaner arms and were overall stronger than the participating women. While the soldiers in this study were required to shoot using a laser simulator for only a limited duration of 20 min, females still reported greater fatigue and exertion. On the other hand, Gillingham et al. (2004) had their sample, a co-ed military reserve unit in Canada, shoot on multiple trials at targets after they endured vigorous exercise and ingested caffeine, but still found no gender differences. However, only 3 of the 12 participants in their study were females.

In contrast, other studies did find support for gender differences in shooting performance. Boyce (1992) required participants who were U.S. university students enrolled in rifle shooting classes—presumed to have little or no previous experience with the task—to shoot at a target from a kneeling position during five sets of trials held over a 3 week period. The results showed that males outperformed females on the first and third sets of trials. Johnson and Merullo (1996), using an army simulator and a more experienced U.S. sample, showed that while males kept the same marksmanship accuracy during 3-h sentry sessions which involved detecting and then firing at targets that appeared infrequently, marksmanship accuracy deteriorated for women after 1.5 h. Lastly, Thompson et al. (1980) conducted a wide range field study for the U.S. Army in order to assess several marksman training programs. Their impressive sample included 910 males and 241 females undergoing entry level shooting instruction. Males were superior to female trainees overall and across all the training programs that were being evaluated.

The Current Study

Among the very few studies of gender performance in rifle shooting cited above, none tested performance during a real competition, incorporated multiple years of measurement, or employed elite rifle shooters. We therefore elected to analyze the performance of NCAA shooters during the NCAA Rifle Championship, an annual competition amongst the leading NCAA rifle shooters. This mixed competition event, involving the best male and female shooters, has been held continuously since 1980 and serves as the feeding system for the U.S. Olympic team (Yost 2012), though also a few non-U.S. sharpshooters take part. Unlike Olympic shooting, however, NCAA rifle shooting has not been segregated.

Using archival data, the present study aimed to investigate gender differences in performance in the NCAA Rifle Championship from the 2007 to 2013 seasons. We analyzed the official score shooters obtained in the team and individual tournaments separately, since previous research indicated that the type of competition can bring about fundamental changes in the competitors. Williams et al. (1989) argued that identifiability was at the basis of the difference. Athletes competing in a team context are relatively anonymous and thus are better shielded from competitive pressure. As individual competitors, this layer of anonymity is absent. In line, Tauer and Harackiewicz (2004) in the U.S. found that participants in basketball made more successful free-throws, on average, when in teams of two as compared to free-throw shots taken alone. Similarly, Cooke et al. (2013) demonstrated in Great Britain that performance, enjoyment, and effort all increased from individual to team competitions.

Since women were found to generally feel less competent than their male counterparts, which, in turn, depressed their performance in mixed gender tournaments (Gneezy et al. 2003), we predicted that males would outperform females shooters in NCAA competitions in all types of rifles [1]. In addition, less upper body strength in women may affect their ability to hold a weapon in a steady manner and indeed the majority of past rifle shooting research with a vastly greater number of participants did find males outdoing females (Boyce 1992; Johnson and Merullo 1996; Thompson et al. 1980). We also predicted that male shooters would especially surpass female competitors in the longer events (i.e., small-bore competitions are slotted as 3 h events while air rifle competitions are slotted as an hour and 45 min events) as females report greater fatigue when shooting a rifle (Kemnitz et al. 1997). In addition, Johnson and Merullo (1996) found that the performance of women shooters deteriorated after 1.5 h of performance at which point the number of targets hit by women was fewer than at the start of the session and significantly fewer than that of men.

We also predicted that the difference in performance would be magnified in the individual tournament [2] for which only the best shooters qualify. In support of our hypothesis, Healy and Pate (2011) showed that females in the U.S. preferred to take part in a team over an individual competition when conducting a mathematical task and that the gender gap was manifested more heavily in individual competitions. In the realm of sports, Martin and Hall (1997) using a North-American sample found that anxiety increased among female figure skaters before taking part in an individual competition relative to a pre-team event. It was also predicted that improved performance in the early round (i.e., team or qualifier tournament) would be associated with better performance during the final individual competition [3] since these scores were included in the overall score for the individual event and may also generate psychological momentum (Iso-Ahola and Blanchard 1986; Iso-Ahola and Mobily 1980). We expected shooting performance to improve when using an air rifle rather than a small-bore rifle [4] because the former is lighter and is fired from a shorter distance (10 m vs. 50 ft [15.24 m]). Kemnitz et al. (1997) demonstrated that soldiers of both genders performed better and prefered the rifle akin in dimensions to the air rifle rather than the model that approximated the small-bore. Also, performance was expected to fluctuate on a yearly basis due to minor rule changes (Boothe et al. 2006; Klimitas et al. 2007, 2008), which were applied similarly to both genders.

Method

Competition Structure

The NCAA is a U.S. sporting governing body which regulates the functioning of the majority of the athletic competitions of universities across the United States. Three tiers of competition exist and students who compete at the two top divisions may be offered financial aid (i.e., scholarships) for playing a sport (National Collegiate Athletic Association, n.d.-a). In 1972 the federal government passed a landmark legislation known as Title IX which prohibited gender discrimination in higher-education institutions receiving federal funds. The law required schools to offer male and female students equal opportunities to play sports and receive their fair shares of athletic scholarship money (Bunker et al. 2000).

The NCAA Rifle Championship is an annual coed competition held in mid-March which is composed of two tournaments: an individual and team events. The team tournament is a competition amongst the top eight qualifying teams in the league (teams become eligible to compete in the tournament during a qualifier held in mid-February).

During the team tournament five shooters on each team must shoot using their own small-bore rifle and air rifle in an indoor range. A small-bore rifle uses gunpowder to propel the projectile, while an air rifle uses air or gas. According to the NCAA rulebooks for the investigated years (Boothe et al. 2006; Klimitas et al. 2007, 2008), a small-bore rifle can weigh up to 8 kg (17.6 lb), while the air rifle can weigh up to 5.5 kg (12.1 lb). There are restrictions on the sizes and lengths of parts of the rifles as well. For example, the air rifle system, which includes the barrel and firing mechanism, cannot exceed 850 mm in length. In contrast, the small-bore rifle does not have a system restriction (although there are restrictions for other parts of the small-bore rifle). There are also rules and restrictions regarding the equipment and clothing that the athletes can use, but none are gender specific. Furthermore, there have been changes to the rules over the investigated years, but none of the changes were gender specific nor were they alterations to the fundamental structure of the competitions.

When shooting a small-bore rifle the competitors shoot a total of 60 shots (20 standing, 20 kneeling, and 20 prone) at a target placed 50 ft (about 15.24 m) away. The targets have concentric circles and a player can score as high as 10 points for each shot, therefore the highest possible score is 600 (200 points from standing position, 200 points from kneeling position, and 200 points from prone position). The small-bore rifle event lasts about 3 h. For the air rifle, shooters take 60 standing shots at a target placed 10 m (about 32.8 ft) away. The scoring system is similar to the small-bore rifle event (highest score is 600 points from the standing position). The air rifle event takes about an hour and 45 min.

The team's total score is the sum of the four best scores in the small-bore and the air rifle events amongst the five team members. For this reason, it is possible for one of the shooters on a team to have either none of their scores, one of their scores, or both of their scores counted in their team's total score. The teams are ranked according to their total score.

Following, the individual tournament is held. A shooter can qualify for this event either prior to or during the team championship. To qualify prior to the individual championship, a shooter must shoot individually at the qualifier event held in mid-February. Only the top eight shooters from the qualifier are selected. To qualify during the championship, a shooter must obtain one of the top eight scores in either rifle type during the team tournament. A shooter can qualify for one or both rifle types. In the individual tournament, the eight shooters who qualified prior to the championship and the eight shooters with the highest scores in each rifle (the top eight in air rifle and the top eight in small-bore rifle) from the team tournament compete against each other. Therefore, there is a total of 24 spots in the individual tournament each year. Each shooter now takes 10 standing shots in an indoor range. For each shot, the highest possible score is 10.9 (the 10-point ring and only the 10-point ring is now subdivided). The highest possible score that can be obtained in the individual tournament is thus 109. The obtained score is added to their score from the team tournament or the qualifier for their final individual score.

Participants

A total of 149 shooters (75 males and 74 females) competed in the seven NCAA Rifle Championships analyzed. Of them, 141 (74 males and 67 females) competed in at least the team competition for 1 year. See Tables 1, 2, and 3 for the number of scores contributed by each gender for each year and rifle type.

Of the 141 shooters in the team competitions, 74 competed in multiple years (36 [26 males and 10 females] competed in 2 years, 23 [12 females and 11 males] competed in 3 years, and 15 [eight females and seven males] competed in 4 years). In the individual competition, 22 shooters competed in multiple years (18 [13 males and five females] competed in 2 years, three [two females and one male] competed in 3 years, and one female competed in 4 years).

The majority of shooters in the sample (123 [64 females and 59 males]) were from the United States, 15 (eight males [four from Sweden, two from Germany, one from Estonia, and one from Italy] and seven females [two from Mexico, one from Norway, one from Germany, one from Poland, one from Canada, and one from Italy]) were from other countries, and the remaining 11 (eight males and three females) could not be determined because the individual school websites did not provide this information. The shooters from the United States originated from 43 states.

Eighteen schools competed in the NCAA Rifle Championships from the 2007 to 2013 seasons. Six schools were only represented in the individual competition. The remaining schools were represented in both the team and individual competitions.

In the individual competition, we analyzed the scores of 70 (38 males and 32 females) shooters who competed over the investigated time period (i.e., the top eight finishers for each rifle type in the individual tournament). Of the identified shooters, 59 (35 males and 24 females) qualified from the team tournament for each year they competed, eight (seven females and one male) qualified prior to the championship for the 1 year they competed, and three (two males and one female) qualified from the team tournament 1 year and prior to the championship another year. See Table 4 for the number of scores each gender contributed each year. See Table 5 for the number of males and females who placed first through eighth each year.

Database

The NCAA online database (National Collegiate Athletic Association, n.d.-b) was the primary source of data (we also relied on the participating schools' websites when data was missing). NCAA Rifle Championships from the 2007 to 2013 seasons were used since the records from earlier years did not list the scores obtained by each individual shooter.

For the individual tournament, the individual final scores (score obtained before the individual tournament [either in the team tournament or the qualifier before the championship]+ score obtained in the individual tournament) were recorded. The score obtained in the individual tournament had to be

Table 1 Mean performances and standard deviations of male and female shooters in the team tournament of the NCAA Rifle Championships

		Year							
		2007	2008	2009	2010	2011	2012	2013	Total
Male	*M*	577.6	578.3	578.4	578.3	578.9	580.6	581.3	579.0
	(*SD*)	(10.95)	(8.65)	(6.63)	(6.69)	(9.11)	(6.57)	(6.67)	(8.12)
	[*n*]	[39]	[32]	[39]	[33]	[35]	[30]	[35]	[243]
Female	*M*	578.2	578.1	576.0	580.2	583.6	582.6	582.5	580.3
	(*SD*)	(7.36)	(7.28)	(5.94)	(8.62)	(6.42)	(6.39)	(7.49)	(7.49)
	[*n*]	[25]	[32]	[25]	[31]	[29]	[34]	[29]	[205]

n number of scores

Table 2 Mean performances and standard deviations of male and female shooters for air rifle scores in the team tournament of the NCAA Rifle Championship

		Year							
		2007	2008	2009	2010	2011	2012	2013	Total
Male	*M*	584.8	582.9	583.5	581.9	583.7	584.5	586.0	583.9
	(*SD*)	(5.79)	(6.49)	(4.36)	(4.12)	(6.64)	(4.53)	(4.09)	(5.25)
	[*n*]	[18]	[15]	[18]	[17]	[17]	[15]	[17]	[117]
Female	*M*	582.5	581.5	578.2	586.1	587.8	586.0	587.8	584.3
	(*SD*)	(5.30)	(5.51)	(4.96)	(6.57)	(4.38)	(4.69)	(3.90)	(5.97)
	[*n*]	[14]	[17]	[14]	[15]	[15]	[17]	[15]	[107]

n number of scores

calculated by subtracting the score attained before the individual tournament from the final score, since only the combined score was reported in the NCAA website. However, the online database did not list the score obtained before the individual tournament for shooters who qualified from the qualifying event (prior to the championships). To determine these missing scores, we searched the competing school websites. There were five scores (from three males and two females) that could not be found and therefore were excluded from the analysis. Furthermore, the NCAA website included only the scores of the top eight finishers in each rifle type for each year (only 16 shooters were thus listed for each year) rather than all 24 finalists. The missing eight finalists each year could not be determined and were also excluded from the analysis. Lastly, we also supplemented the data provided by the NCAA database with information from the competing schools pertaining to the gender of the shooters.

Results

We employed a generalized estimating equation (GEE) to account for the correlation between multiple observations in the dataset. Since some shooters participated in the tournament in multiple years, a traditional regression method could not be used for the risk of violating the statistical assumption of the independence of observations (Ghisletta and Spini 2004). GEE is a conservative statistical procedure (Hardin and Hilbe 2003) that was introduced as a method of analyzing correlated data, as it is advised not to treat observations from the same cluster as if they were independent, thus allowing for more efficient estimators of regression parameters. The main advantage of GEE is the yielding of reasonably accurate confidence intervals since it does not explicitly model between-cluster variation but rather estimates the within-cluster similarity of the residuals, and then uses this estimated correlation to re-evaluate the regression parameters and to calculate standard errors (Hanley et al. 2003). We used IBM SPSS version 19 to conduct the analyses.

The first four analyses conducted pertained to the NCAA team competition. The database was composed of 448 individual scores from the team tournament (7 years [2007–2013] X 8 qualifying teams X 8 recorded scores). Overall, we had 141 unique shooters, of which 30 contributed only one score. Half of the scores (n=224) were for the small-bore rifle and the other half for the air rifle. Males contributed 243 (54.2 %) while females provided 205 (45.8 %) scores.

Table 6 shows the results of the regression utilizing the individual score within the team competition as the outcome variable controlling for same player observations. As

Table 3 Mean performances and standard deviations of male and female shooters for small-bore rifle scores in the team tournament of the NCAA Rifle Championship

		Year							
		2007	2008	2009	2010	2011	2012	2013	Total
Male	*M*	571.5	574.4	574.1	574.4	574.4	576.7	576.9	574.5
	(*SD*)	(10.66)	(8.49)	(4.90)	(6.87)	(8.96)	(6.03)	(5.58)	(7.68)
	[*n*]	[21]	[17]	[21]	[16]	[18]	[15]	[18]	[126]
Female	*M*	572.6	574.3	573.2	574.6	579.0	579.2	576.9	575.9
	(*SD*)	(5.78)	(7.28)	(6.10)	(6.38)	(5.01)	(6.15)	(6.15)	(6.49)
	[*n*]	[11]	[15]	[11]	[16]	[14]	[17]	[14]	[98]

n number of scores

Table 4 Mean performances and standard deviations of male and female shooters in the individual tournament of the NCAA Rifle Championship

		Year							
		2007	2008	2009	2010	2011	2012	2013	Total
Male	*M*	98.00	99.82	98.66	99.17	100.96	99.76	99.72	99.25
	(*SD*)	(3.52)	(3.45)	(2.88)	(2.64)	(3.54)	(1.17)	(3.43)	(3.19)
	[*n*]	[14]	[11[a]]	[10]	[3[a]]	[7[a]]	[5]	[6]	[56]
Female	*M*	96.85	96.60	98.30	100.53	100.06	100.25	100.20	99.63
	(*SD*)	(2.19)	(4.71)	(3.93)	(2.63)	(3.41)	(2.00)	(4.15)	(3.36)
	[*n*]	[2]	[4]	[6]	[11[a]]	[7[a]]	[11]	[10]	[51]

n number of scores

[a] One score was excluded because the score obtained could not be determined

Table 5 Gender, place, and year of shooters in the individual competition of the NCAA Rifle Championship

Year	Gender	Rifle Type	Place								*n*
			1st	2nd	3rd	4th	5th	6th	7th	8th	
2007	Male	Air	1	1	1	1	1	1	1	1	8
		Small-bore	1	–	1	1	1	1	–	1	6
	Female	Air	–	–	–	–	–	–	–	–	–
		Small-bore	–	1	–	–	–	–	1	–	2
2008	Male	Air	1	1	1	–	1	1	–	1	6
		Small-bore	1	1	1	1	–	–	1	1	6
	Female	Air	–	–	–	1	–	–	1	–	2
		Small-bore	–	–	–	–	1	1	–	–	2
2009	Male	Air	–	1	1	1	1	1	–	1	6
		Small-bore	1	–	–	–	1	1	1	–	4
	Female	Air	1	–	–	–	–	–	1	–	2
		Small-bore	–	1	1	1	–	–	–	1	4
2010	Male	Air	1	–	–	–	–	–	–	–	1
		Small-bore	–	1	1	–	–	1	–	–	3
	Female	Air	–	1	1	1	1	1	1	1	7
		Small-bore	1	–	–	1	1	–	1	1	5
2011	Male	Air	1	–	1	–	1	–	–	–	3
		Small-bore	1	1	–	1	1	–	–	1	5
	Female	Air	–	1	–	1	–	1	1	1	5
		Small-bore	–	–	1	–	–	1	1	–	3
2012	Male	Air	–	–	–	–	–	1	–	1	2
		Small-bore	–	1	–	1	–	–	1	–	3
	Female	Air	1	1	1	1	1	–	1	–	6
		Small-bore	1	–	1	–	1	1	–	1	5
2013	Male	Air	–	–	1	1	–	–	–	–	2
		Small-bore	–	1	–	1	–	1	1	–	4
	Female	Air	1	1	–	–	1	1	1	1	6
		Small-bore	1	–	1	–	1	–	–	1	4
Total	Male	Air	4	3	5	3	4	4	1	4	28
		Small-bore	4	5	3	5	3	4	4	3	31
	Female	Air	3	4	2	4	3	3	6	3	28
		Small-bore	3	2	4	2	4	3	3	4	25

n number of scores

Table 6 Generalized estimating equation model predicting an individual score within the team competition phase of the NCAA Rifle Championship (Linear Logistic)

Parameter	B	S.E. range	95 % Wald CI	Sig.
Rifle Type [Air/ Small-bore]	8.96	0.50	7.98–9.92	.00*
Gender [Males/Females]	−0.78	0.80	−2.36–0.80	.33
Year	0.80	0.19	0.43–1.17	.00*
Intercept	572.36	1.04	570.33–574.39	.00*

The degrees of freedom (df) for all the variables is 1

*p<.01

hypothesized [4], those who used an air rifle (M=584.1) outperformed those who shot the small-bore rifle (M=575.1; p<0.01). Shooting performance throughout the years also fluctuated (p<0.01). Most importantly, contrary to our hypothesis [1], there was no statistical difference between the genders, with females (M=580.3) performing as well as males (M=579.0; p=0.33). We also conducted the analysis excluding the international competitors (see Table 7) since they may constitute a distinct subgroup based on their qualifications and recruitment but, again, we failed to find any gender differences (p=.15).

Since there are differences between the air rifle and small-bore events, we decided to analyze the two events separately as well. Table 8 shows the results of the GEE regression analysis for the individual air rifle scores within the team competition as the outcome variable controlling for same player observation. Similar to the previous results, there was still no significant difference in performance between males (n=117, M=583.9) and females (n=107, M=584.3, p=.66). Lastly, we analyzed separately the small-bore team competitions performance in which we predicted that females would be especially deficient due to the long duration of the event [1]. Table 9 shows the results of the GEE regression analysis utilizing the individual small-bore rifle scores within the team competition as the outcome variable controlling for same player observation. Again, contrary to our hypothesis, there

Table 7 Generalized estimating equation model predicting an individual score for U.S. shooters only within the team competition phase of the NCAA Rifle Championship (Linear Logistic)

Parameter	B	S.E. range	95 % Wald CI	Sig.
Rifle Type [Air/ Small-bore]	8.82	0.54	7.77–9.87	.00*
Gender [Males/Females]	−1.19	0.81	−2.78–0.41	.15
Year	0.77	0.19	0.40–1.14	.00*
Intercept	572.24	1.06	570.17–574.31	.00*

The degrees of freedom (df) for all the variables is 1

*p<.01

Table 8 Generalized estimating equation model predicting an individual air rifle score within the team competition phase of the NCAA Rifle Championship (Linear Logistic)

Parameter	B	S.E. range	95 % Wald CI	Sig.
Gender [Males/Females]	−0.36	0.82	−1.96–1.24	.66
Year	0.71	0.19	0.33–1.09	.00*
Intercept	581.45	1.01	579.46–583.43	.00*

The degrees of freedom (df) for all the variables is 1

*p<.01

was no significant difference in performance between males (n=126, M=574.5) and females (n=98, M=575.9, p=.26).

Next, we analyzed the performance of the best shooters who qualified for the individual competition. In the 7-year span 112 scores were available (59 contributed by male and 53 by female shooters). All in all, we could identify 70 shooters (38 males and 32 females) who took part, of which 29 had multiple scores (19 males contributed 40 scores and 10 females contributed 31 scores). Forty-one shooters contributed only one score (19 males and 22 females).

The analysis was conducted using 107 scores obtained in the individual tournament (excluding 5 missing data points). About half of the valid scores (n=54) were from the small-bore rifle events and the rest (n=53) from the air rifle events. Thirty-seven male shooters contributed 56 (52.3 %) valid scores while 31 female athletes provided 51 (47.7 %) valid observations. See Table 4 for the mean performance during the individual tournament and number of scores by year. See Table 10 for the mean performance prior to the individual tournament.

We, again, employed a GEE analysis for the final round of performance within the individual competition as the outcome variable controlling for same player observations (see Table 11). Once again, those who used an air rifle (M=101.41) outperformed those who shot the small-bore rifle (M=97.41; p<0.01) [4]. Contrary to our hypothesis, the scores achieved by the shooters prior to the individual competition (either in the qualifier or team competition) did not correlate with the final individual round of

Table 9 Generalized estimating equation model predicting an individual small-bore rifle score within the team competition phase of the NCAA Rifle Championship (Linear Logistic)

Parameter	B	S.E. range	95 % Wald CI	Sig.
Gender [Males/Females]	−1.19	1.05	−3.25–0.88	.26
Year	0.88	0.27	0.36–1.40	.00*
Intercept	572.26	1.35	569.63–574.90	.00*

The degrees of freedom (df) for all the variables is 1

*p<.01

Table 10 Mean performances and standard deviations prior to the individual tournament of male and female shooters in the individual tournament of the NCAA Rifle Championship

		Year							
		2007	2008	2009	2010	2011	2012	2013	Total
Male	*M*	585.9	586.5	585.5	582.3	589.6	588.2	587.0	586.5
	(*SD*)	(4.70)	(4.48)	(4.06)	(1.16)	(5.74)	(2.59)	(4.56)	(4.50)
	[*n*]	[14]	[11[a]]	[10]	[3[a]]	[7[a]]	[5]	[6]	[56]
Female	*M*	579.5	586.0	583.2	588.6	589.4	589.2	589.8	587.9
	(*SD*)	(0.71)	(4.69)	(3.76)	(5.43)	(4.43)	(2.86)	(4.37)	(4.83)
	[*n*]	[2]	[4]	[6]	[11[a]]	[7[a]]	[11]	[10]	[51]

n number of scores

[a] One score was excluded because the score obtained could not be determined

performance (p=0.07) [3]. Most notably, and against our prediction [2], there was no statistical difference between the genders, with females (M=99.63) performing as well as males (M=99.25; p=0.38). We also conducted the analysis excluding the international competitors (see Table 12) but similarly failed to find any gender differences (p=.40). Given the correlated nature of the data, we did not pursue separate analyses by rifle type for the individual competition since the number of the participants was too small to produce statistically sound analyses.

Discussion

We repeatedly (in both rifle types) found no gender difference in rifle shooting performance during the team tournament. Furthermore, when the top-performers competed for the individual honors (presumably under even higher levels of stress because they were no longer anonymous members of their teams), there were still no gender differences in performance. The results were similar also when elite international shooters were excluded from the analyses.

Table 11 Generalized estimating equation model predicting the final round performance within the individual competition phase of the NCAA Rifle Championship (Linear Logistic)

Parameter	B	S.E. range	95 % Wald CI	Sig.
Rifle Type [Air/ Small-bore]	3.05	0.63	1.80–4.29	.00*
Gender [Males/Females]	0.42	0.48	−0.51–1.36	.38
Score Prior to Individuals	0.14	0.07	−0.01–0.28	.07
Year	0.33	0.13	0.06–0.59	.02**
Intercept	15.96	43.33	−68.96–100.88	.71

The degrees of freedom (df) for all the variables is 1

**p*<.01

***p*<.05

Our findings of the absence of gender disparities in shooting performance stand in contrast to most past research (Boyce 1992; Johnson and Merullo 1996; Thompson et al. 1980) but are in line with some other findings (Gillingham et al. 2004; Kemnitz et al. 1997). It is important to note that all past studies explored shooting performance by employing participants, rifle types and environments which were much different than the current investigation. Thus, when competing directly against others in a rifle shooting competition with real rifles (rather than a simulated setting) and shooting indoors, we find that the gender gap does not exist and we conclude that physiological differences between the genders do not have a significant effect in the competitions studied.

Notably, the best females also performed on par with male shooters in the subsequent, prestigious individual competition. We found that scores from the earlier rounds did not correlate with scores achieved in the individual tournament phase despite being heavily factored into the final score. This finding supports the notion that the individual stage of the competition is unique (i.e., no evidence for psychological momentum effects from the prior event) and may present challenges that are different than those in the team setting. Similar to our results, Cooke et al. (2013) showed that the effects of the competition conditions (i.e., individual vs. team) were alike for males and females in Great Britain on a handgrip endurance task.

The current results stand seemingly in contrast to recently emerging findings (Croson and Gneezy 2009; Gneezy et al. 2003) suggesting the existence of differences in the competitive nature between the genders. However, the findings of the current study are in line with a more recent result by Dreber et al. (2011), who found that Swedish boys and girls competed equally in running as well as in skipping rope and dancing, thereby failing to replicate earlier outcomes by Gneezy and colleagues. Future research should determine if the nature of the task (e.g., open vs. closed skill execution) must also be considered when assessing the gender gap in performance, as variables such as risk aversion and confidence may differ between types of sports (Boheim and Lackner 2013).

Table 12 Generalized estimating equation model predicting the final round performance for U.S. shooters only within the individual competition phase of the NCAA Rifle Championship (Linear Logistic)

Parameter	B	S.E. range	95 % Wald CI	Sig.
Rifle Type [Air/ Small-bore]	3.54	0.72	2.13–4.95	.00*
Gender [Males/Females]	0.44	0.52	−0.58–1.46	.40
Score Prior to Individuals	0.09	0.10	−0.10–0.28	.37
Year	0.28	0.14	0.06–0.56	.046**
Intercept	45.28	55.60	−63.71–154.26	.41

The degrees of freedom (df) for all the variables is 1

*p<.01

**p<.05

Unlike previous research in rifle shooting (Boyce 1992; Gillingham et al. 2004; Kemnitz et al. 1997), the present investigation incorporated multiple years of measurement of highly skilled competitive shooters during intense competition. However, we only studied a relatively short period of time (i.e., 7 years of NCAA Rifle Championships). Past archival research (Seiler et al. 2007; Tatem et al. 2004) found contradictory results because databases of varying time spans and scopes were employed. Future studies should, therefore, revisit gender performance in the NCAA to provide a more comprehensive and informed outlook. In addition, future research should include a survey-based approach probing female and male shooters about their subjective perceptions of competing with and against the opposite gender. It is clear that diverse empirical approaches—perhaps involving field experiments—can enrich our understanding of gender differences in performance outcomes. Combining the insights from each methodology should help illuminate the circumstances under which physiological, psychological and environmental factors take effect when the genders compete in mixed sporting events.

Researchers can also focus in the future on other Summer Olympic sports in which women compete with men (i.e., mixed events), although these sports do not readily lend themselves to explorations of the gender gap. Namely, tennis and badminton are gender segregated (International Olympic Committee, n.d.-a) but allow for mixed-doubles events in which performance analysis by gender is difficult. Women have also been competing with men in various equestrian events (e.g., dressage, jumping) but it is hard to separate the contribution of the horse versus that of the rider in assessing gender performance in this sport. Lastly, future research could focus on segregated sports that were not previously analyzed, but might allow gender comparisons. For example, while archery is kept segregated, the rules of distance and number of attempts are consistent across gender. The similarity to rifle shooting makes this sport especially intriguing to study but the ordinal measurement scoring system (i.e., the better shooter is awarded the higher score in head-to-head elimination competitions) makes, yet again, direct comparison between the genders difficult (if not impossible) to study.

USA Shooting, which oversees the development of U.S. National teams that compete in the Olympic Games on behalf of the United States, issued a recent position statement (USA Shooting 2012) following criticism over the segregation of rifle shooting in the Olympics (Yost 2012). It argued that while anecdotal history did suggest that there was no gender gap in shooting performance, it was important to also note that since the sport became segregated the number of female participants has grown exponentially (from 14 in the 1976 and 1980 Olympic Games combined to 145 in the 2008 Games, while the number of shooting events contested has grown from six in 1980 to 15 in 2012). Thus, the position statement argued, the "Opportunities for women to compete in Olympic shooting have not shrunk with the dissolution of 'mixed' events, but rather have grown as a result" (para 4), and that this increase, in turn, should assist with greater female participation in the sport (as well as with hunting and firearms use), alter the stereotype that shooting was a mostly male pursuit and make manufacturers more likely to produce shooting gear tailored for women. However, this position, we find, undermines the core premise of Olympic sports in which the best athlete, man or woman, should prevail. Using this same logic one can argue that racial desegregation of U.S. Major League Baseball (i.e., the first time Black players were allowed to compete against their White counterparts) in 1947 was detrimental since the Negro leagues in which the Black players played before integration folded soon after (Lanctot 2008). Lastly, there is ample research, originating mostly from North-America (Lockwood 2006; Marx and Roman 2002; McIntyre et al. 2005), to demonstrate that successful female role models who compete equally with their opposite gender counterparts in perceived male-dominated domains are paramount in exerting remarkable positive effects on other females.

Is Olympic shooting a case of "separate but (un)equal" then? Compared to male shooting events, female Olympic shooters are required to perform at a lower level by taking fewer shots or shooting at a closer distance to the target. For example, in the pistol event men shoot from a distance of 50 m while women are positioned 25 m from the target. In the air rifle competition, the distance (10 m) is kept constant across genders but men take 60 shots while women take 40 shots (USA Shooting 2012). The findings of the present study strongly suggest that the Olympic committee is pursuing a separate but (un)equal doctrine and that Olympic Shooting should be desegregated (three female shooters from our sample went on to represent the U.S. and Italy in the Olympic Games), as gender discrimination is particularly incompatible with the fundamental Principles of Olympism (International Olympic Committee 2011).

In the practical sense, if the Olympic organizers are concerned with female shooters not performing on par with their male counterparts, they can keep the competitions separate but implement similar rules of distance and number of shots on target across gender (i.e., true equality) for a limited period of time to assess gender performance differences in the Olympics.

While it may be postulated that the gender segregation practiced in the Olympics currently is a by-product of the untested implicit belief of male superiority in sports (Eagly 1985), we argue that the practice is more likely to reflect blatant discrimination. A case in point is that of Zhang Shan (International Olympic Committee, n.d.-b), a Chinese skeet shooter, who in the 1992 Olympic Games won the gold in her event and became the first woman to win a non-segregated shooting event all the while setting a new world record (USA Shooting 2012). Skeet shooting and trap shooting were the only events that were kept mixed following the gender segregation in the sport since 1984. Following this great achievement, the International Shooting Union (now the International Shooting Sport Federation), which governs the Olympic shooting events, decided to segregate all the events and would not allow women to compete in skeet shooting during the 1996 Olympics at all. Female skeet shooters were permitted to compete again in the 2000 Olympics, but this time only in their own segregated event.

In conclusion, our findings call into question current Olympic gender segregation practices in shooting events. The lack of differences in performance between the genders among elite NCAA shooters both in team and individual competitions in mixed gender events should start a discussion among policy makers about the origins of the practice at the Games; explore alternative ways to study the phenomenon and then suggest possible remedies.

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