



# **NAVAL POSTGRADUATE SCHOOL**

**MONTEREY, CALIFORNIA**

## **THESIS**

**ALTERING THE GENDER COMPOSITION IN THE  
MARINE CORPS: RECRUITING AND READINESS  
IMPLICATIONS**

by

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June 2018

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**ALTERING THE GENDER COMPOSITION IN THE MARINE CORPS:  
RECRUITING AND READINESS IMPLICATIONS**

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## **ABSTRACT**

As of January 2016, all military occupations opened to women across all branches of military service. The opening of previously closed occupations to women has initiated conversations regarding how the quality of the force may be affected by the integration. This study explores the implications of altering the gender composition in the Marine Corps on recruiting and readiness. To address recruiting implications, we examine the differences in the predicted probabilities of the average male and female civilian graduating from the Infantry Training Battalion. We find that the average male civilian is 5.2 times more likely to graduate from the Infantry Training Battalion than the average female civilian. To address readiness implications, we examine the differences in average availability between males and females during their first term of service, and we also analyze the differences between availability in females across different occupational fields. We find that on average, females are less deployable than males during the first four years of service, with the differences peaking during months 25–36, with the major cause of a female's unavailability being pregnancy. We further find that the density of females does not have a significant effect on the overall readiness of the female population.

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## LIST OF ACRONYMS AND ABBREVIATIONS

|          |                                                       |
|----------|-------------------------------------------------------|
| AFQT     | armed forces qualification test                       |
| AWOL     | absence without leave                                 |
| CFT      | combat fitness test                                   |
| DC, M&RA | Deputy Commandant, Manpower & Reserve Affairs         |
| FY       | fiscal year                                           |
| GCEITF   | ground combat element integrated task force           |
| HFZ      | healthy fitness zone                                  |
| IDES     | integrated disability evaluation system               |
| ITB      | infantry training battalion                           |
| MCOTEA   | Marine Corps operational test and evaluation activity |
| MCT      | Marine combat training                                |
| MOS      | military occupational specialty                       |
| NCHS     | National Center for Health Statistics                 |
| PCS      | permanent change of station                           |
| PEBD     | pay entry base date                                   |
| PFT      | physical fitness test                                 |
| PMOS     | primary military occupational specialty               |
| RAND     | research and development                              |
| SEAL     | sea, air, and land                                    |
| SOC      | standard occupational classification                  |
| SOCOM    | special operations command                            |
| SOI      | school of infantry                                    |
| TFDW     | total force data warehouse                            |
| USMC     | United States Marine Corps                            |
| UUID     | universally unique identifier                         |

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## I. INTRODUCTION

### A. ALL MILITARY OCCUPATIONS OPEN TO WOMEN

The history of women's participation in the Marine Corps dates back to 1918 when Opha Mae Johnson officially became the first woman to enlist in the United States Marine Corps. Almost a hundred years later, in 2017, three women became the first female infantry Marines (Task & Purpose, 2017). Women's involvement in the labor force has radically changed in the past century, stimulated by wartime demands in the early 1900s, which accelerated the social changes that were already underway (Greenwald, 1990). Despite the steady incline of female involvement in male-dominated industries, females make up only approximately 8% of the active duty Marine Corps personnel. Of all the services, the Marine Corps is composed of the smallest percentage of females. Women make up anywhere between 14% to 20% of the active duty population in the other services (Department of Defense, 2016), as shown in Figure 1.

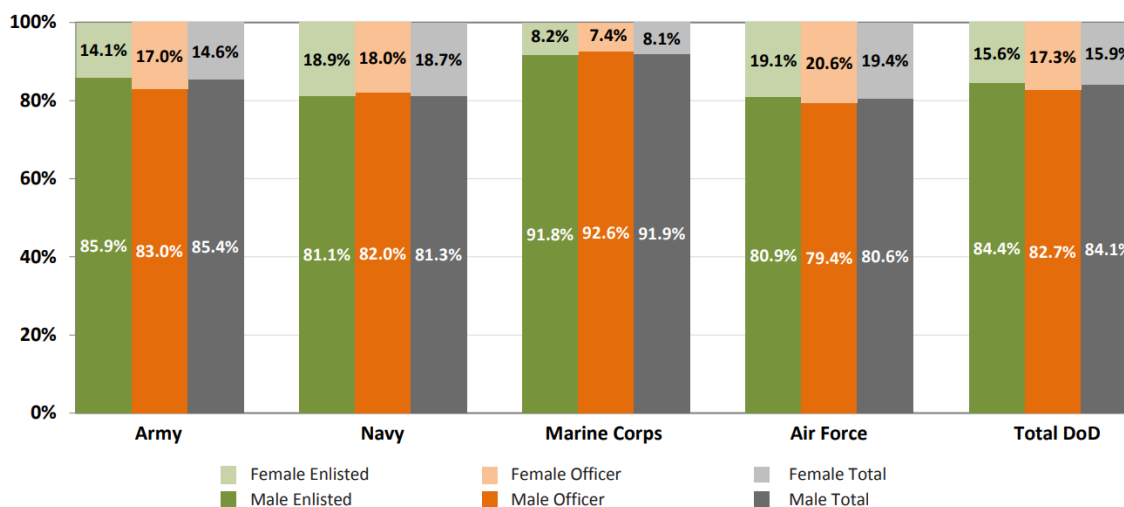


Figure 1. Percentage of Active Duty Members by Service Branch and Gender.  
Source: Department of Defense (2016).

In 2015, as senior leaders discussed lifting the limitations on women's involvement in the military, the Marine Corps conducted a gender integration study and subsequently requested an exception for several combat occupational specialties based on the results. However, then Secretary of Defense Ash Carter reiterated that no exceptions would be made, and beginning January 2016, all military occupations and positions opened to women across every branch of military service (Pellerin, 2015).

## **B. ANSWERING THE IMPOSSIBLE QUESTION**

The response to the ban lift will include integration plans for positions that were previously closed to women, and many considerations must be made to ensure that the focus is in the right place. Overlooking potential unintended consequences could be costly on many levels, not only to the productivity of individual services but to the security of our nation. For these reasons, the secretary of defense provided guidelines for the implementation process:

1. Implementation will be pursued with the objective of improved force effectiveness.
2. Leaders must assign tasks and jobs throughout the force based on ability, not gender.
3. Equal opportunity likely will not mean equal participation by men and women in all specialties, and there will be no quotas.
4. Studies conducted by the services and SOCOM indicate that on average there are physical and other differences between men and women, and implementation will take this into account.
5. The department will address the fact that some surveys suggest that some service members, men and women, will perceive that integration could damage combat effectiveness.
6. Particularly in the specialties that are newly open to women, survey data and the judgment of service leader indicate that the performance of small teams is important.
7. The United States and some of its closest friends and allies are committed to having militaries that include men and women, but not all nations share this perspective. (Pellerin, 2015, para. 13)

Shortly after Secretary Carter's announcement, the Marine Corps received direction from the Commandant to increase the percentage of females to 10% (Bennett, 2016): "I've told them that 10 percent is where we want to go and they're working on it. Go recruit more women. Find them. They're out there" (Bennett, 2016, para. 3). The question we want to focus on may not be whether we can have 10% of the force composed of women, but what that might entail. Determining what the right percentage of females would look like in the Marine Corps requires an ultimate objective. For example, the guidelines for the implementation process stress the importance of focusing on force effectiveness. However, the force effectiveness of a military is a product of a myriad of factors: physical abilities, cognitive abilities, technology, adaptability, readiness, leadership, and cohesion are just a few of the diverse and numerous factors. To try to quantify what "ideal" number of females would produce the best output of effectiveness without addressing all such factors would be greatly underestimating the complexity of this issue. Furthermore, addressing each of those factors will have severe limitations, as Chapter 2 will discuss.

Although the discussion is a difficult one with many uncertainties, blurred lines, and unquantifiable notions, it would be irresponsible to forge ahead without deliberate consideration as to how we might get closer to a more satisfying answer. An attempt to improve decision-making even at the margins would be worth doing because it deals with manpower, our most valuable resource. Thus, despite the difficulties in quantifying the benefits and costs of altering the gender composition, failing to do so may result in the service expending too many additional resources in order to recruit and retain female Marines beyond the optimal number or conversely, not expending enough resources to recruit and retain females where the benefits would outweigh the costs.

This study is not a formal cost benefit analysis due to the breadth of the scope and the limitations already stated; instead, it acts as a framework for a cost benefit analysis by looking at two factors that affect force effectiveness: recruiting and readiness. This study accomplishes this by analyzing the pool of individuals and the physical abilities of those individuals that the Marine Corps has to draw from for future accessions in order to compare the intensity of effort that must be expended to recruit females in comparison to males. Furthermore, this study examines the differences in deployability between males

and females in order to see how readiness may be affected by changes in the current gender composition.

### **C. RESEARCH OBJECTIVE**

The objective of this study is to examine the implications of altering the gender composition on recruiting and readiness. We consider the implications on recruiting by analyzing the pool of potential candidates that the Marine Corps recruits from to estimate the predicted probability of success in graduating from the School of Infantry (SOI) for the average civilian. The estimated probability provides an avenue of approach to understand the intensity of effort that must be expended to alter the gender composition within the Marine Corps. We consider the implications on readiness by analyzing the differences in deployability between males and females to determine the potential effects that a change in gender composition may have on the force's readiness.

### **D. ORGANIZATION OF STUDY**

This report is organized into five chapters. Chapter 2 discusses the existing literature relating to women in the labor market and how group composition can affect performance. Chapter 3 analyzes the data and methodology. Chapter 4 discusses the results. Chapter 5 proposes recommendations and concludes the report.

## **II. LITERATURE REVIEW**

This chapter discusses existing literature in two separate sections. The first section addresses studies related to females in the labor market both in the civilian and military sectors. The second section frames the problem through an economist's lens.

### **A. WOMEN IN THE LABOR MARKET**

#### **1. Population Fit for Service**

The changing landscape of the American population continues to present new challenges for military recruiting. In their paper, Cawley and Maclean (2011) discuss that between 1959–62 and 2007–08, the percent of eligible male civilians who exceeded weight and body fat requirements for the Army rose from 5.55% to 11.70%. For females, the percent who exceeded weight and body fat requirements rose from 11.46% to 34.65% (Cawley & Maclean, 2011). With a dwindling labor supply from which the military can draw their recruits, particularly for females, the Marine Corps will have to consider what increasing the number of females might mean from the recruiting perspective.

A thesis by two Marines at the Naval Postgraduate School examines the predictive factors of success and failure for enlisted Marines at the Infantry Training Battalion (ITB) in order to facilitate the efforts of the Marine Corps in selecting the most qualified Marines. According to Dove & Richmond (2017), predictors of success that are statistically significant are Armed Forces Qualification Test (AFQT) scores, physical fitness test (PFT) scores, combat fitness test (CFT) scores, rifle scores, height, and weight, and predictors of failure that are most significant are physical performance and physical health. Their study recommends that leadership should expend efforts to place significance on physical and mental abilities at recruiting stations during the screening process. Due to the correlation between fitness test scores and a Marine's follow-on success at ITB, they come to the conclusion that it is imperative to maintain the highest of standards for all Marines, regardless of gender, entering infantry training.

The importance of physical fitness and health in the success of Marines and the trend of obesity in the United States present great challenges for military recruiting as the

pool of potential candidates shrinks due to the services' body weight and height standards and physical fitness requirements. As the labor supply dwindles, the pool of civilian females may be a relatively untouched resource that the Marine Corps could tap into to face recruiting challenges. In order to meet the manpower needs of the military, the conversation needs to shift from whether integrating more women will lower the standards to where we might be able to draw the most number of high quality candidates, regardless of gender.

## **2. Diversity in Teams**

An extensive literature attempts to answer the question about the importance diversity plays in the performance of a team or its effects on group behavior. Diversity may refer to various characteristics of the individuals that belong to a team such as demographics, abilities, opinions, or even personalities (Witte, 1996). Witte cites a wide range of social psychological studies conducted on the effects of composition on group work and analyzes how composition can influence group structure, dynamics, and performance. Studies both in the civilian and military sectors attempt to address how performance may be affected by gender composition. For example, a study (see Aidman, 2017) analyzes the advantage of diverse teams in ultra-endurance events. Results show that the most successful teams consist of mixed-gender groups. The study also reveals that the top-performing teams sought out cognitive advantages, which were supposedly gained through qualities more often found in women, such as the ability to balance team dynamics, high pain tolerance, inclination for burden sharing, and decision-making through exhaustion. Studies like these tend to advocate for diversity and argue that heterogeneous groups maintain an advantage over homogeneous ones due to flexibility, inclination for innovation, and ultimately, increased group performance (Witte, 1996).

Diversity does not come without risk, however, as it can weaken cohesion due to increased conflict, especially if the diversity is forced on group members (Witte, 1996). Furthermore, certain tasks may be better suited for diverse groups than others. The complexity of the task and the coordination requirements, for example, may favor heterogeneous teams over homogenous ones or vice versa (Witte, 1996). Other studies

show a different narrative about diversity's effect on performance (see Joshie & Roh, 2009). Joshie and Roh (2009) find that "in occupations dominated by men or by white employees, gender and ethnic diversity had more negative effects on performance outcomes" (p. 618).

As an organization that places value on flexibility, innovation, group performance, and cohesion with a myriad of tasks at varying levels of complexity and coordination requirements, the Marine Corps' priority on the topic of gender diversity can be convoluted. Recently, the Marine Corps attempted to look at the effects of gender composition on performance by forming the Ground Combat Element Integrated Task Force (GCEITF), and the study focused on the costs of integration to combat effectiveness.

The Marine Corps formed the GCEITF under the Commandant's authorization from July 2014 to July 2015. The task force integrated female Marine volunteers into a combat arms unit in order to assess the unit's performance while the female volunteers performed the duties of military occupational specialty skills that were closed to females during the time of the study (MCOTEA, 2015). The study included 300 male and 100 female volunteers, who were split into groupings of all-male squads and mixed-gender squads. The squads performed tasks, which were meant to act as a proxy for determining combat effectiveness, and the results show that in 69% of the tasks, the all-male squads outperformed the integrated squads (MCOTEA, 2015).

As mentioned earlier, the force effectiveness of a military is a product of a myriad of factors: physical and cognitive abilities, technology, adaptability, readiness, leadership, and cohesion are just a few of these factors. The GCEITF study mainly uses physical abilities as a proxy for combat effectiveness, which does not address the remainder of the factors that may contribute to a unit's effectiveness on a regular basis. Critics claimed that the study was flawed in its execution and that only results that supported keeping women out of combat roles were shared (Walters, 2015). Of course, addressing the remainder of the factors may further emphasize the costs of integrating more females into the Marine Corps, but there may also be benefits that are overlooked by focusing on only one aspect of combat effectiveness.

There are various limitations to the study as the Experimental Assessment Report outlines, such as self-selection bias and insufficient sample size. Since the study was strictly voluntary, the results may not reflect the true average performance of each gender population. For example, it is possible that the female volunteers that agreed to participate in the study were more likely to perform better than their female peers. If this holds true, the observed differences between male and female performance are likely reduced in magnitude than the true differences. At the same time, the same could be said about the male volunteers, in which case it would be impossible to say in what direction the differences are biased without knowing the magnitude of the bias for each gender.

Furthermore, due to the methods of gathering data through surveys for fatigue and workload, there may be measurement errors from inaccurate self-reporting either over- or underestimating one's own fatigue or workload levels. Additionally, the perception of unit cohesion may have been altered by an individual's existing view on integrating women into combat roles. Regardless, the study attempts to account for such limitations where feasible and ultimately finds that integrated units are slower to achieve tasks when compared to all-male units, and that females are not able to perform physically demanding tasks "at the same level as their male counterparts in terms of performance, fatigue, workload, or cohesion" (MCOTEA, 2015, p. ES-1). The study also concludes that females are more likely to suffer occupational injuries while males are more likely to suffer non-occupational injuries.

### **3. Compensation Differentials**

Individuals make choices regarding occupation based on payoffs, to include monetary wages and non-pecuniary benefits. For example, differing wage rates between genders in certain occupations may cause women to seek out opportunities elsewhere. Historical discrimination trends may also continue to contribute to decreased concentration of women in that field. The discussion on gender wage differentials in the military labor market deviates from the typical conversation in the civilian labor market mainly due to the fact that the base pay received by a member is the same at each rank regardless of gender. Negotiation for a higher pay between the employer and employee is nonexistent

and the employer does not have the option to over- or undervalue their employee's work by means of increased or reduced base pay. However, a wage gap may exist due to incentives or bonuses that may be more likely to be had by one gender than another. For example, Hattiangadi, Ackerman, Kimble, & Quester (2004) discuss how those in occupational specialties that are considered to be more challenging, such as combat arms MOSs, typically receive bonuses because they may be less likely to reenlist.

A wage gap may also be the result of the likelihood of a gender to promote faster than the other. A RAND study found that in fiscal year 2009, the proportion of females that progressed to senior leadership remained relatively low in comparison to males (Asch, Miller, & Malchiodi, 2012). A more recent study in 2012 similarly found that "women are less likely to be promoted and are generally less likely to stay given promotion up to and including the O5 milestone" (Asch et al., 2012, p. 21). Figure 2 shows results from the RAND study that display that the percentage of white male officers who are promoted from O1 to O2, O2 to O3, O3 to O4, and O4 to O5 are consistently higher when compared to white female officers. Similarly, retention at the O2, O3, O4, and O5 level is consistently higher in male officers when compared to white female officers.

There are various potential explanations for the disparity in representation of women in certain MOS fields or promotion rates between male and female Officers. For example, Delus (2017) examines how critical mass of female Marines within particular military occupational specialties may affect attrition. Thus, the lack of power in numbers for the female population may be negatively affecting retention (Delus, 2017). As for promotion, some hypothesize whether certain barriers may be affecting women's abilities to promote at the same rate as their male peers. Zimmer (1988) argues that tackling tokenism or altering the gender proportion in work groups will not suffice in having sufficient female representation in male-dominated occupations due to the existence of sexism.

| Milestone    | Percentage of White Male Officers Retained/<br>Promoted | Percentage Point Difference:<br>Minority Female Officers – White Male Officers |               |                  |                        |  |
|--------------|---------------------------------------------------------|--------------------------------------------------------------------------------|---------------|------------------|------------------------|--|
|              |                                                         | White Females                                                                  | Black Females | Hispanic Females | Other Minority Females |  |
| Promotion    |                                                         |                                                                                |               |                  |                        |  |
| O1 to O2     | 98.5                                                    | −0.8***                                                                        | −1.5***       | −1.8***          | −0.9***                |  |
| O2 to O3     | 91.2                                                    | −2.5***                                                                        | −0.2          | −1.8**           | −1.7***                |  |
| O3 to O4     | 76.0                                                    | −3.2***                                                                        | −3.9***       | −1.8             | −3.7**                 |  |
| O4 to O5     | 74.6                                                    | 0.6                                                                            | −6.8***       | −6.4             | −3.3                   |  |
| O5 to O6     | 46.9                                                    | 3.4**                                                                          | −7.7**        | 13.1             | 16.6**                 |  |
| Retention as |                                                         |                                                                                |               |                  |                        |  |
| O1           | 99.8                                                    | 0.0                                                                            | −0.1          | −0.3***          | −0.2***                |  |
| O2           | 99.3                                                    | −0.4***                                                                        | −0.2*         | 0.2              | −0.2                   |  |
| O3           | 70.1                                                    | −10.9***                                                                       | 4.2***        | −4.7**           | −3.7**                 |  |
| O4           | 87.9                                                    | −3.5***                                                                        | −0.5          | 2.5              | −0.4                   |  |
| O5           | 81.4                                                    | −10.9***                                                                       | −5.7**        | −9.6             | −8.8*                  |  |

NOTE: \*\*\* = statistically significant from zero at the 1 percent level; \*\* = statistically significant from zero at the 5 percent level; \* = statistically significant from zero at the 10 percent level.

Figure 2. Differences in the Likelihood of Reaching Promotion/Retention Milestones. Source: Asch et al. (2012).

#### 4. Quota-Based Policies

The topic of women entering male-dominated fields of work typically brings to mind words and phrases like affirmative action and equal opportunity. Haley & Sidanius (2006) discuss various research showing that responses to policies associated with affirmative action can be radically different based on how the policy is framed. For example, they find that when affirmative action programs focus on outcomes rather than opportunities, people tend to oppose such programs. Similarly, programs that are framed in terms of preferential, rather than equal, treatment tend to be unsupported (Haley & Sidanius, 2006). It is not surprising that criticism about lowered standards and poor quality have surfaced during these discussions surrounding quota-based policies.

In response to the Commandant's direction, the Marine Corps began efforts to raise the percentage of females to 10% from the current 8% (Bennett, 2016). Expectedly, critics voiced concerns about lowering standards in order to meet the new diversity goal. Quotas and workplace goals are often associated with sacrificing quality (see Arkes & Cunha,

2014; Dove & Richmond, 2017; Challinor, 2015). In their paper, Arkes & Cunha (2014) examine how workplace goals for recruiters may affect output quality of recruits. They find that as the number of days left in the recruiting month decrease, the quality of the contract, measured by AFQT score and education level, also decreases. Additionally, they find that the end-of-month effect is even larger for females; females signed in the last three days of the recruiting month have an AFQT score that is 1.845 points lower than those that were signed within the first half of the recruiting month. In comparison, males signed in the last three days of the recruiting month have an AFQT score that is 0.926 points lower than those signed within the first half of the recruiting month (Arkes & Cunha, 2014).

A master's thesis by Challinor (2015) examines the costs of integrating women into the Navy SEALs. The study looks at the options between an equal opportunity policy with selection based on merit and a quota-based policy. The study's findings show that for a merit-based policy, the tangible costs for a female SEAL graduate would be an additional \$2,411,865.72 while for a quota-based policy, it would be an additional \$2,230,687.70 for each female SEAL graduate. Although the tangible costs are lower for the quota-based policy, the study argues that the intangible costs such as injury, opportunity costs, tokenism, morale, team cohesion, and a decrease in mission effectiveness are more prevalent in the quota-based policy, and would outweigh any advantage of having more women pumped through the pipeline.

## **B. ECONOMIC MODELS**

### **1. The Production Function**

With fifty thousand previously closed billets now open to women, the future composition of the Marine Corps has the potential to drastically differ from its current makeup. For the first time in history, a woman could theoretically fill every billet in the Marine Corps should she meet the standards required. That said, the natural following question is regarding what composition of manpower will yield the ideal structure. In order to answer this question, the “ideal” needs to be defined.

As an entity under the Department of Defense, the Marine Corps fills a role in the nation's defense policy, and the dialogue on women's involvement in the military cannot

be had without addressing its mission: to defend the people of the United States, at home and abroad. Although this mission can be dissected into further compartments of different ways we achieve the mission, ultimately, we are talking about our role as the nation's force in readiness. As described in the Marine Corps Vision & Strategy 2025 by the United States Marine Corps (2008), "a force in readiness must be well-trained, broadly educated, and properly equipped for employment across all forms of warfare" (p. 2).

If we look at this issue through an economist's lens, we can liken the Marine Corps to a firm. In theory, a "firm is an entrepreneurial unit committed to some degree to the production of a specific output. The theory of the firm involves its decisions as to the level of its output and the particular resource combination to employ" (Kirzner, 1963, p. 149). Thus, the Marine Corps would equate to the firm with readiness or combat effectiveness being the specific output it is looking to produce. The number of females and males to employ is the resource that can be adjusted in various combinations to affect the level of output. Of course, other factors affect readiness. If we were to come up with an all-encompassing production function that shows the relationship between the inputs that affect readiness, the number of males and females would only be part of such an equation. For example, according to Hayward (1968), the probability of success on the battlefield is determined by the following: human factors, competency in job, capabilities of the force, nature of the enemy, combat environment, and mission. According to his model, the ratio of males to females would fall under only one of the identified factors: the capabilities of the force. This study will not be attempting to measure the combat effectiveness of the force based on all such factors. The focus will simply be on the alternatives of employing men versus women.

Despite focusing on solely these two alternatives, the problem still is not a simple one to address. For example, consider the information needed to draw the production function with readiness as the output and the number of females as the input as shown in Figure 3. If our imaginary curve represents readiness to females, our slope of the curve would show us the tradeoff, if such a tradeoff exists, between increasing the number of females to the Marine Corps' readiness. The shape of the curve in Figure 3 would infer that there is some level of combat effectiveness that exists with zero females in the Marine

Corps, but an increase in females would increase combat effectiveness up to a certain point. This increase may be attributed to diversity of personnel, which may positively contribute to innovation or adaptability. Females may also bring more empathy to an organization, which improves leadership and thus, combat effectiveness. However, the curve also falls after a certain point, which would mean that beyond an ideal percentage of females, combat effectiveness would again fall as more of the force is made up of females. Once females make up the entirety of the force, combat effectiveness is lower than if the force were made up completely of males. This may be due to the fact that the average female is physically less capable of carrying a load than the average male can carry, and thus an infantry unit made up of all females would be slower to move than a unit made up of all males. Before we could attempt to draw the actual curve that represents combat effectiveness as a function of the percent of females, we would need to understand the substitutability between our two factors in the production of combat effectiveness.

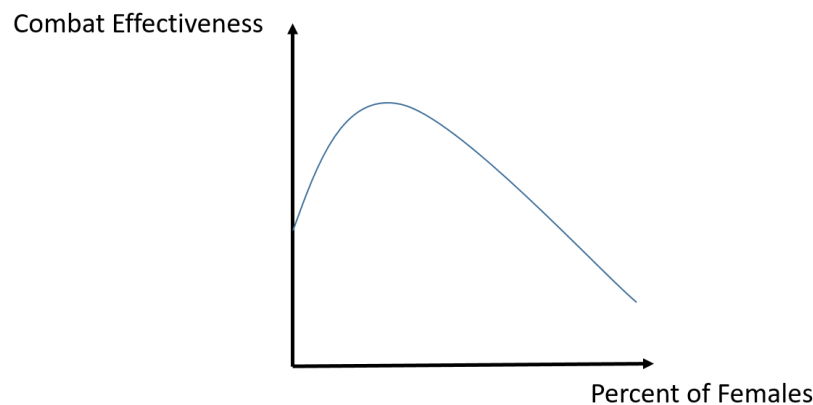


Figure 3. Hypothetical Production Function Relating Combat Effectiveness to Percent of Females

Let us consider two extreme examples shown in Figure 4. In Figure 4(a), the L-shape of the isoquant depicts what the isoquant would look like if there were no substitutability between our two factors, males and females. For example, the output of G requires the input of *AB* from factor F and *AD* from factor M. In order to achieve an output

of H, there must be an increase of  $BC$  from factor F and an increase of  $DE$  from factor M. If we were to increase only our factor of F, no matter how much we increased it, output could not be lifted until we increased M as well. This L-shaped isoquant, therefore, illustrates a scenario where the level of output would depend on the combination of a fixed quantity of each factor (Kirzner, 1963). The example Kirzner provides is a pair of scissors with the two blades as the component parts. We know this is not true in the Marine Corps. We do not require an arbitrary quantity of males and females as components to a unit in order to increase our output of combat effectiveness. Furthermore, if we could infinitely increase the number of either men or women in the Marine Corps (in a hypothetical situation where budget and other constraints did not exist), we would be able to increase our capabilities with the increased manpower even if we could not increase the number of the other gender. Thus, we know that some degree of substitutability exists between our two factors.

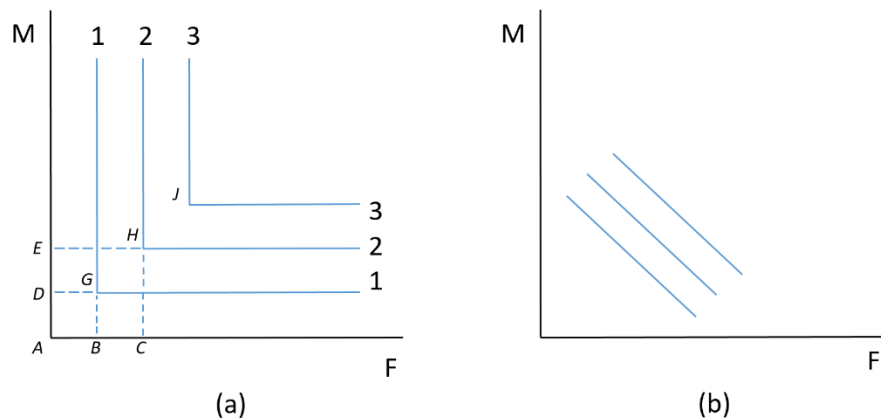


Figure 4. Shape of the Isoquants

Now, let us consider the opposite extreme that Figure 4(b) depicts. In this scenario, our two factors are perfect substitutes. The isoquants here illustrate that the same increase in either factor can always be made in order to achieve an increase in output. In any situation, adding an additional quantity of one factor would provide the same increase in level of output as adding the same additional quantity of the other factor. There are certainly

jobs in the Marine Corps where this may hold true, but we know this is not necessarily accurate across all communities. For example, if we accept that the average male will be able to carry a heavier load capacity than the average female, in an infantry unit where the ability to bear heavy loads may affect mission accomplishment, adding an additional average female to the unit may not indicate the same level of output as adding an additional male.

Since we know that the isoquant that depicts substitutability between men and women will not look like either of the extreme cases of (a) and (b), we can determine that the shape of the isoquant will fall somewhere in between. In order to draw this specific isoquant, however, we would need to know the marginal rate of substitution for our factors. The explanation of the isoquants above should illustrate the difficulty of this task. As already mentioned, if we were to look at an infantry unit, the marginal rate of substitution may look drastically different from the rate for a maintenance unit. It would probably be expected that the marginal rate of substitution of women for males might be much higher in a combat community than the marginal rate of substitution of women for males in a community that relies less on physiological makeup of the individual for job execution. Thus, there are probably different isoquant shapes for different communities within the Marine Corps.

If we were to disaggregate the objective function to these individual communities, perhaps the isoquant for one occupational community may show that men and women behave more like substitutes whereas in another community, the isoquant may look more similar to Figure 4(a). Nevertheless, without knowing exactly what the marginal rates of substitution are, we will never be able to draw the exact isoquants.

Although we lack the knowledge required to measure and draw these isoquants, we can get some sense of differences in productivity of male and female Marines. In order for a Marine to contribute substantially to the Marine Corps' mission, we argue that they must be available for deployment when the call comes. Common reasons a Marine may be unavailable for deployment include initial training, medical conditions, and pregnancy. In Chapters 4 and 5, we measure differences in deployability between male and female Marines as a proxy for their contribution to the production function.

## **2. Roy Model**

Even in a hypothetical situation where we could draw the exact isoquants that show the substitutability between men and women in every military occupational community within the Marine Corps, this would only tell half the story: the labor demand. Knowing the marginal rate of substitution between men and women in each community would give the Marine Corps the requisite information to target the right number of males and females for any given MOS. On the other side of the story is the knowledge issue with labor supply.

In his paper, Roy (1951) examines the behavior of workers and how they would self-select into occupations based on their level of skills and how these skills are correlated in the population. The application of the Roy Model may provide us insight with how the Marine Corps' labor market may behave in handling the opening of fifty thousand new jobs that were previously closed to women. Studies by economists such as Heckman and Sedlacek (1985) and Bacolod (2007) use the Roy model to examine how self-selection may affect labor markets as individuals make decisions based on maximizing their own utility. Utility may refer to wages, but it may also include other factors such as leisure time or the amount of effort an individual would need to put in to a specific job.

In our current discussion, the returns include more than simply wages, since, as described earlier, a Marine receives the same monetary compensation in base pay as their fellow peers. However, although the base pay does not change between individuals in the same rank, there are incentives and bonus pays that may be more frequently associated with certain jobs over others; thus, overall wage differences may be seen across MOSs. Furthermore, there may be nonpecuniary benefits that play an even larger role in an individual's choice of occupation within the Marine Corps. The difficulty of a job, the prestige one would get by being associated with a particular community, or the pride of doing something difficult may all be factors that fall under an individual's utility. It is possible that those that are enticed to join the Marine Corps are motivated by such intangible benefits more than money in their willingness to join and subsequently, their decision-making for choosing an MOS.

The factors that individuals consider in order to choose their MOS will not be the same for any two individuals, but we know that all individuals will be looking to maximize their utility. Roy (1951) uses an example of two occupations, hunting and fishing, to illustrate how skill levels and the correlation of such skills will cause individuals to move into one occupation over the other. Similarly, with the opening of the previously closed MOSs, we can consider how the differences in productivity of males and females in these occupations may affect the gender composition of such communities. Although some of the jobs in the military may not have a counterpart in the civilian sector, seeing how the civilian market has organized itself may give us insight as to how females may self-select into specific occupational communities despite the opening of all MOSs.

The civilian labor market is essentially a free market where individuals can choose their occupation with arguably lower barriers to entry than the military. As noted earlier, civilians are not required to move and PCS every three years, maintain required levels of combat and physical fitness, etc. Yet, the female representation remains low in the civilian occupations that map to the MOSs that were previously gender restricted prior to the 2013 integration mandate. While there may be a desire to increase female representation across the USMC as a whole, I find that many MOSs have mapped SOC's that sit below the current eight percent Corps-wide female representation level. This data can thus provide realistic expectations for gender integration goals as I predict that female representation in USMC MOS' will remain lower than the related civilian occupation. (Zunic, 2018, p. 53)

Although we have not had enough time to view how females will perform in these new billets, viewing the issue from the perspective of the labor supply may provide us with realistic expectations to the additional limitations we may be faced with, despite the Marine Corps' desire to increase female representation across all MOSs. No studies have been completed yet, to my knowledge, to attempt identifying the ideal number of females in the Marine Corps. Although my study will not provide an exact number to this impossible question, this study will provide a framework in meeting that end and further the discussions needed with the factors and constraints that exist in order to make an informed manpower decision regarding gender composition.

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### **III. DATA AND METHODOLOGY**

This chapter discusses the data and methodology within two different sections. The first section describes the data and methodology used for the “street to fleet” analysis, which focuses on the pool of potential civilians who may enter the Marine Corps. The second section describes the data and methodology used for “in the fleet” analysis, which focuses on the individuals who have been recruited and are in training to become Marines or are serving as active duty members.

#### **A. STREET TO FLEET**

All recruits must go through boot camp in order to earn the title of “Marine.” After boot camp, all Marines attend the School of Infantry (SOI). SOI consists of two different training schools: Infantry Training Battalion (ITB) and Marine Combat Training (MCT). Marines pursuing an MOS in the combat arms go to ITB and all other non-combat MOS Marines go to MCT.

In order to analyze the current pool of potential enlistees in the context of fulfilling combat arms roles, we used data from ITB-West, the National Center of Health Statistics (NCHS), and California’s Department of Education to estimate the predicted probability of the average male and female civilian graduating from ITB. Dove & Richmond (2017) found that predictors of success that were statistically significant were AFQT scores, PFT scores, CFT scores, rifle scores, height, and weight, and predictors of failure that were most significant were physical performance and physical health. Since AFQT scores, CFT scores, and rifle scores do not have sufficient parallel data within the NCHS and California’s Department of Education data, we focused on the separate events that make up the PFT scores (pull-ups, crunches, and run time), height, and weight to estimate the predicted probability of graduating from ITB.

## 1. ITB-West

The data from ITB-West included 1,973 observations of enlisted Marines who went through ITB in one of seven classes between October 5, 2016 and February 22, 2017, as shown in Table 1.

Table 1. Breakout of ITB Cohorts

| Convene Date | Freq. | Percent |
|--------------|-------|---------|
| 5-Oct-16     | 257   | 13.03   |
| 19-Oct-16    | 296   | 15      |
| 9-Nov-16     | 283   | 14.34   |
| 14-Dec-16    | 300   | 15.21   |
| 11-Jan-17    | 244   | 12.37   |
| 1-Feb-17     | 299   | 15.15   |
| 22-Feb-17    | 294   | 14.9    |
| Total        | 1,973 | 100     |

In order to estimate the predicted probability of successfully graduating from ITB, we ran the following logistic regression, using the variables shown in Table 2:

$$\text{GRAD} = B_0 + B_1 * \text{PullUps} + B_2 * \text{Crunches} + B_3 * \text{MileRun} + B_4 * \text{HT} + B_5 * \text{WT}.$$

Subsequently, we estimated the predicted probability of graduation for the average civilian female and male by using the marginal probabilities from the logit model. The values we used for the predicted probability will be explained in the next section.

Table 2. Variables from ITB-West Dataset

| Variable | Description                                                      |
|----------|------------------------------------------------------------------|
| GRAD     | Binary; 0 if they did not graduate and 1 if they graduated       |
| PullUps  | # of pull-ups completed during physical fitness test (PFT); 0-20 |
| Crunches | # of crunches completed during PFT; 0-100                        |
| MileRun  | Time in which 3 mile run was completed during PFT                |
| HT       | Height in inches                                                 |
| WT       | Weight in pounds                                                 |

Some restrictions to this dataset must be addressed. All of the Marines in this dataset are males, so a logistic regression could not be run for a female population within ITB. However, staying true to the conversation of equal standards across the board simplifies this issue. Although 20 pull-ups were not required for a female to max out their PFT score, being able to complete 20 pull-ups would likely indicate upper body strength that contributes to the duties that an infantry Marine, regardless of gender, may be expected to carry out. Thus, the marginal probabilities used to calculate the predicted probability for graduation was based off the logistic regression results of the all-male population at ITB.

## **2. NCHS / California Department of Education**

In order to develop the civilian equivalent averages for the above variables, we retrieved data through NCHS for the average height and weight in individuals at age 17. In order to estimate what the average number of pull-ups, crunches, and mile run time would be for the population, we used data from the state of California's physical fitness tests. The state of California's Education Code mandates that all students in grade nine run a PFT in order to evaluate their fitness. The test uses standards that "represent a level of fitness that offers some protection against the diseases associated with physical inactivity" (Fitnessgram: Healthy fitness zone charts, n.d., Purpose and Content para. 5). The goal is for students to achieve scores that fall in the Healthy Fitness Zone (HFZ) for six different assessment areas.

Based on the summary of results in the 2016-2017 Physical Fitness Report, shown in Table 3, the majority of the students in each grade were in the HFZ. For example, for grade nine, 61.9% were in the HFZ for aerobic capacity, 82.6% were in the HFZ for abdominal strength, and 70.9% were in the HFZ for upper body strength. Although grade nine students are typically in the age range of 14 to 15 years old, and we ideally want to see the performance of 17 year olds, the California PFT is only conducted up to grade nine. Thus, there may be some limitation in using physical performance results of 14 to 15 year olds as indicators for physical fitness two years later. Although it is not absolutely certain whether this limitation would overestimate or underestimate the predicted probability of

17+-year-old civilians graduating from ITB, we would probably expect it to underestimate the predicted probability given that students in grade 12 are likely more physically mature and thus able to score higher on their PFTs than they were able to two years earlier. The standards for meeting the HFZ standards, however, are the same for females between the ages 14 to 17 for the assessment areas we are concerned with. For males, there is a difference in 5 pull-ups for the upper body strength and endurance assessment area from ages 14 to 17. We used the age 17+ standards for the male pull-ups since this is the age closest to which an individual will likely enlist out of high school. In order to get the predicted probability of graduation for the average female and average male, we used the information from Table 4, Table 5, and the average height and weight from NCHS.

Table 3. 2016-2017 California PFT Grade 9 Summary of Results. Adapted from Fitnessgram: Healthy Fitness Zone Charts (n.d.).

| Assessment Category | Total Tested | Number in HFZ | % in HFZ |
|---------------------|--------------|---------------|----------|
| Aerobic Capacity    | 445,003      | 275,564       | 61.9     |
| Abdominal Strength  | 445,003      | 367,488       | 82.6     |
| Upper Body Strength | 445,003      | 315,590       | 70.9     |

Table 4. Female Healthy Fitness Zone Performance Standards.  
Source: Fitnessgram: Healthy Fitness Zone Charts (n.d.).

| Age | Abdominal Strength and Endurance:<br>Curl-Up<br>(# completed) | Trunk Extensor Strength and Flexibility:<br>Trunk Lift<br>(# of inches) | Upper Body Strength and Endurance:<br>Push-Up<br>(# completed) | Upper Body Strength and Endurance:<br>Modified Pull-Up<br>(# completed) | Upper Body Strength and Endurance:<br>Flexed-Arm Hang<br>(# of seconds) | Flexibility:<br>Back Saver Sit & Reach<br>(# of inches) | Flexibility:<br>Shoulder Stretch |
|-----|---------------------------------------------------------------|-------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------|----------------------------------|
| 5   | ≥ 2                                                           | 6 – 12                                                                  | ≥ 3                                                            | ≥ 2                                                                     | ≥ 2                                                                     | 9                                                       | Yes*                             |
| 6   | ≥ 2                                                           | 6 – 12                                                                  | ≥ 3                                                            | ≥ 2                                                                     | ≥ 2                                                                     | 9                                                       | Yes*                             |
| 7   | ≥ 4                                                           | 6 – 12                                                                  | ≥ 4                                                            | ≥ 3                                                                     | ≥ 3                                                                     | 9                                                       | Yes*                             |
| 8   | ≥ 6                                                           | 6 – 12                                                                  | ≥ 5                                                            | ≥ 4                                                                     | ≥ 3                                                                     | 9                                                       | Yes*                             |
| 9   | ≥ 9                                                           | 6 – 12                                                                  | ≥ 6                                                            | ≥ 4                                                                     | ≥ 4                                                                     | 9                                                       | Yes*                             |
| 10  | ≥ 12                                                          | 9 – 12                                                                  | ≥ 7                                                            | ≥ 4                                                                     | ≥ 4                                                                     | 9                                                       | Yes*                             |
| 11  | ≥ 15                                                          | 9 – 12                                                                  | ≥ 7                                                            | ≥ 4                                                                     | ≥ 6                                                                     | 10                                                      | Yes*                             |
| 12  | ≥ 18                                                          | 9 – 12                                                                  | ≥ 7                                                            | ≥ 4                                                                     | ≥ 7                                                                     | 10                                                      | Yes*                             |
| 13  | ≥ 18                                                          | 9 – 12                                                                  | ≥ 7                                                            | ≥ 4                                                                     | ≥ 8                                                                     | 10                                                      | Yes*                             |
| 14  | ≥ 18                                                          | 9 – 12                                                                  | ≥ 7                                                            | ≥ 4                                                                     | ≥ 8                                                                     | 10                                                      | Yes*                             |
| 15  | ≥ 18                                                          | 9 – 12                                                                  | ≥ 7                                                            | ≥ 4                                                                     | ≥ 8                                                                     | 12                                                      | Yes*                             |
| 16  | ≥ 18                                                          | 9 – 12                                                                  | ≥ 7                                                            | ≥ 4                                                                     | ≥ 8                                                                     | 12                                                      | Yes*                             |
| 17  | ≥ 18                                                          | 9 – 12                                                                  | ≥ 7                                                            | ≥ 4                                                                     | ≥ 8                                                                     | 12                                                      | Yes*                             |
| 17+ | ≥ 18                                                          | 9 – 12                                                                  | ≥ 7                                                            | ≥ 4                                                                     | ≥ 8                                                                     | 12                                                      | Yes*                             |

\* Touching fingertips together behind the back on both the right and left sides.

≥ The score is greater than or equal to the indicated value

≤ The score is less than or equal to the indicated value

Table 5. Male Healthy Fitness Zone Performance Standards.  
Source: Fitnessgram: Healthy Fitness Zone Charts (n.d.).

| Age | Abdominal Strength and Endurance:<br>Curl-Up (# completed) | Trunk Extensor Strength and Flexibility:<br>Trunk Lift (# of inches) | Upper Body Strength and Endurance:<br>Push-Up (# completed) | Upper Body Strength and Endurance:<br>Modified Pull-Up (# completed) | Upper Body Strength and Endurance:<br>Flexed-Arm Hang (# of seconds) | Flexibility:<br>Back Saver Sit & Reach (# of inches) | Flexibility:<br>Shoulder Stretch |
|-----|------------------------------------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------|------------------------------------------------------|----------------------------------|
| 5   | ≥ 2                                                        | 6 – 12                                                               | ≥ 3                                                         | ≥ 2                                                                  | ≥ 2                                                                  | 8                                                    | Yes*                             |
| 6   | ≥ 2                                                        | 6 – 12                                                               | ≥ 3                                                         | ≥ 2                                                                  | ≥ 2                                                                  | 8                                                    | Yes*                             |
| 7   | ≥ 4                                                        | 6 – 12                                                               | ≥ 4                                                         | ≥ 3                                                                  | ≥ 3                                                                  | 8                                                    | Yes*                             |
| 8   | ≥ 6                                                        | 6 – 12                                                               | ≥ 5                                                         | ≥ 4                                                                  | ≥ 3                                                                  | 8                                                    | Yes*                             |
| 9   | ≥ 9                                                        | 6 – 12                                                               | ≥ 6                                                         | ≥ 5                                                                  | ≥ 4                                                                  | 8                                                    | Yes*                             |
| 10  | ≥ 12                                                       | 9 – 12                                                               | ≥ 7                                                         | ≥ 5                                                                  | ≥ 4                                                                  | 8                                                    | Yes*                             |
| 11  | ≥ 15                                                       | 9 – 12                                                               | ≥ 8                                                         | ≥ 6                                                                  | ≥ 6                                                                  | 8                                                    | Yes*                             |
| 12  | ≥ 18                                                       | 9 – 12                                                               | ≥ 10                                                        | ≥ 7                                                                  | ≥ 10                                                                 | 8                                                    | Yes*                             |
| 13  | ≥ 21                                                       | 9 – 12                                                               | ≥ 12                                                        | ≥ 8                                                                  | ≥ 12                                                                 | 8                                                    | Yes*                             |
| 14  | ≥ 24                                                       | 9 – 12                                                               | ≥ 14                                                        | ≥ 9                                                                  | ≥ 15                                                                 | 8                                                    | Yes*                             |
| 15  | ≥ 24                                                       | 9 – 12                                                               | ≥ 16                                                        | ≥ 10                                                                 | ≥ 15                                                                 | 8                                                    | Yes*                             |
| 16  | ≥ 24                                                       | 9 – 12                                                               | ≥ 18                                                        | ≥ 12                                                                 | ≥ 15                                                                 | 8                                                    | Yes*                             |
| 17  | ≥ 24                                                       | 9 – 12                                                               | ≥ 18                                                        | ≥ 14                                                                 | ≥ 15                                                                 | 8                                                    | Yes*                             |
| 17+ | ≥ 24                                                       | 9 – 12                                                               | ≥ 18                                                        | ≥ 14                                                                 | ≥ 15                                                                 | 8                                                    | Yes*                             |

\* Touching fingertips together behind the back on both the right and left sides.

≥ The score is greater than or equal to the indicated value

≤ The score is less than or equal to the indicated value

#### a. *Pull-Ups and Crunches*

For pull-ups and crunches, the results of the fitness test do not display how many pull-ups or curl-ups the individual was able to complete, but simply shows the minimum number they must complete in order to meet the HFZ standards. We used the scores that individuals would need to reach in order to attain the HFZ for pull-ups and curl-ups, which are 4 and 18 respectively for females and 14 and 24 respectively for males. However, these numbers represent the minimum standards, so the individuals may have reached higher scores for each event, which could underestimate the predicted probability for the average individual. However, the pull-ups portion is labeled as “modified” pull-up, so the number

of dead hang pull-ups that the individuals can attain on a Marine Corps PFT may be much lower, which could overestimate the predicted probability for the average individual. The magnitude to which the predicted probabilities may be underestimated or overestimated is difficult to identify without knowing the true results of the pull-ups and curl-ups assessments or how the modified pull-up compares to the Marine Corps pull-up.

**b. MileRun**

For the run times displayed in Tables 6 and 7, the HFZ standards are measured by VO2 max, which does not indicate the time it took for the individuals to run one mile. Due to the limitations of the existing data, we allowed STATA to use the sample average for this variable where the appropriate information could not be found to calculate a value. Thus, the predicted probabilities are using the sample average for the variable, “MileRun,” which is likely lower than the actual average for the civilian population. If this holds true, similar to the modified pull-up issue, using the “MileRun” average may overestimate the predicted probability of graduating ITB for the average, civilian individual.

Table 6. Female One-Mile Run Healthy Fitness Zone Standards.  
Source: Fitnessgram: Healthy Fitness Zone Charts (n.d.).

| One-Mile Run / 20m PACER / Walk Test (VO <sub>2</sub> Max) |                |             |        |
|------------------------------------------------------------|----------------|-------------|--------|
| Age                                                        | NI-Health Risk | NI          | HFZ    |
| 10                                                         | ≤ 37.3         | 37.4 – 40.1 | ≥ 40.2 |
| 11                                                         | ≤ 37.3         | 37.4 – 40.1 | ≥ 40.2 |
| 12                                                         | ≤ 37.0         | 37.1 – 40.0 | ≥ 40.1 |
| 13                                                         | ≤ 36.6         | 36.7 – 39.6 | ≥ 39.7 |
| 14                                                         | ≤ 36.3         | 36.4 – 39.3 | ≥ 39.4 |
| 15                                                         | ≤ 36.0         | 36.1 – 39.0 | ≥ 39.1 |
| 16                                                         | ≤ 35.8         | 35.9 – 38.8 | ≥ 38.9 |
| 17                                                         | ≤ 35.7         | 35.8 – 38.7 | ≥ 38.8 |
| 17+                                                        | ≤ 35.3         | 35.4 – 38.5 | ≥ 38.6 |

Table 7. Male One-Mile Run Healthy Fitness Zone Standards.  
Source: Fitnessgram: Healthy Fitness Zone Charts (n.d.).

| One-Mile Run / 20m PACER / Walk Test (VO <sub>2</sub> Max) |                |             |        |
|------------------------------------------------------------|----------------|-------------|--------|
| Age                                                        | NI-Health Risk | NI          | HFZ    |
| 10                                                         | ≤ 37.3         | 37.4 – 40.1 | ≥ 40.2 |
| 11                                                         | ≤ 37.3         | 37.4 – 40.1 | ≥ 40.2 |
| 12                                                         | ≤ 37.6         | 37.7 – 40.2 | ≥ 40.3 |
| 13                                                         | ≤ 38.6         | 38.7 – 41.0 | ≥ 41.1 |
| 14                                                         | ≤ 39.6         | 39.7 – 42.4 | ≥ 42.5 |
| 15                                                         | ≤ 40.6         | 40.7 – 43.5 | ≥ 43.6 |
| 16                                                         | ≤ 41.0         | 41.1 – 44.0 | ≥ 44.1 |
| 17                                                         | ≤ 41.2         | 41.3 – 44.1 | ≥ 44.2 |
| 17+                                                        | ≤ 41.2         | 41.3 – 44.2 | ≥ 44.3 |

**c. Height and Weight**

We used data from the National Center for Health Statistics for the average height and weight of females and males, which show that the mean height for 17-year old females is 64 inches and 68.9 inches for males. The mean weight for 17-year old females is 148.5 pounds and 165.5 pounds for males.

**B. IN THE FLEET**

In order to analyze gender differences for individuals who have been recruited and begun training or are currently active duty, we use two different datasets from the Total Force Data Warehouse (TFDW) to explore the differences in deployability between males and females, and then to examine the differences in deployability for females across differing occupational fields. The first dataset includes every active duty Marine, pulled by Fiscal Year (FY) snapshots from FY 2000 to FY 2017, which contains 3,427,047 observations. The information we need from this first dataset are the Marine's pay entry base date (PEBD) and MOS. The second dataset includes all active duty Marines, pulled by monthly snapshot observations from the beginning of FY 2010 to the end of FY 2017, which contains 16,940,523 observations. The information we use from this second dataset are the individual's deployability category (see Table 8) and gender.

Table 8. Deployability Categories

| Code | Deploy Category                                                     |
|------|---------------------------------------------------------------------|
| 1    | All Other Training                                                  |
| 2    | Available                                                           |
| 3    | AWOL                                                                |
| 4    | Combat Wounded - waiver granted                                     |
| 5    | Conscientious Objector                                              |
| 6    | Enrolled in IDES                                                    |
| 7    | Humanitarian Duty                                                   |
| 8    | Initial Entry Training                                              |
| 9    | Legal Action                                                        |
| 10   | Medical condition that limits full duty                             |
| 11   | Patient (assigned to "Individual Account")                          |
| 12   | Permanent Limited Duty                                              |
| 13   | Pregnancy (including post partum)                                   |
| 14   | Prisoner (incarcerated > 30 days and < 6 months) (assigned to "IA") |
| 15   | Separations (awaiting admin separation & expiration of enlistment)  |
| 16   | Service Discretion                                                  |
| 17   | Service member under 18                                             |
| 18   | Sole Survivor / Surviving Family Member                             |
| 19   | Transient (PCS)                                                     |
| 20   | Unable to Carry a Firearm                                           |

In order to analyze deployability differences between the observations, we re-shaped the second dataset so that each row was a unique UUID and the columns display the months from October 2009 to September 2017. For each UUID, the column cells are the individual's deployable status for that month. Before we analyzed this dataset, we normalized the arrangement so that the first column represented each individual's first month of service. To do this, we had to merge the PEBD from the first dataset to the second dataset so that we could identify each individual's first month of service. The identifier that linked both datasets are the individual's UUID. However, since the first dataset was pulled by FY snapshots, there were some individuals with multiple PEBDs. Since the re-shaped dataset was organized by unique UUID, we could only tie one PEBD to each individual.

We made some sample restrictions in order to associate one PEBD to each UUID. There were a total of 688,243 unique UUID and PEBD combinations in the first dataset,

and 24,892 UUIDs had PEBD shifts. Since PEBD shifts may represent a break in service, we dropped the observations which have a PEBD shift of more than 30 days or multiple shifts. For those that had a shift of less than 31 days, we deleted the last occurrence so that the earlier PEBD is associated with the UUID. This left us with 675,263 unique UUID and PEBD combinations. Then, we dropped all observations that had a PEBD prior to October of 2009 since we did not want to compare an individual whose training pipeline was behind them to an individual who is undeployable for several months due to their initial entry training. We merged this with the re-shaped dataset so that each unique UUID had a PEBD associated with it. As expected, there were UUIDs in the reshaped data that had no match from the UUID-PEBD pairs since we had dropped anyone with a PEBD of earlier than October 2009 and those with PEBD shifts. There were also approximately 5,000 observations that were not in the UUID-PEBD pairs, which may be due to brand new accessions who had not been around long enough to obtain an annual observation.

Once normalized, the first month showed the deployability status for every individual's first month of service instead of the first month of observation. By re-shaping the dataset in this way, we compare everyone's availability starting at each individual's first month, regardless of which FY cohort he or she belonged to. Once normalized, no individual had his or her first month displaying "NA" since month 1 represented the individual's first month of service. Any "NA" in the following months thus indicated an individual separating from the Marine Corps.

Lastly, in order to analyze differences in deployability that may be due to an individual's MOS, we merged the PMOS data from the first dataset to the normalized dataset. Since the first dataset had multiple observations for some UUIDs as they were observed over several FYs, there were some UUIDs which had multiple primary MOSs (PMOS) likely due to lateral transfers. When merged with the normalized dataset, which had only unique UUIDs, it resulted in each unique UUID having several observations with different FYs and different MOSs. We dropped anything that was not a PMOS, and for the remaining UUIDs that still had multiple PMOSs, we picked the earliest MOS that was assigned to them. The final merged dataset included the variables as outlined in Table 9 and contained 232,324 observations.

Table 9. Variable Definitions for TFDW Data

| Variable        | Description                   |
|-----------------|-------------------------------|
| UUID            | Universal Unique Identifier   |
| Deploy Category | See Table 9                   |
| Gender          | Gender of Marine              |
| Cohort FY       | The year of the Marine's PEBD |
| PEBD            | Date Marine began service     |
| MOS             | Marine's MOS                  |

As we analyzed the differences in availability between females and males, and then the differences in availability for females in different occupational fields, we had to make restrictions to the data we looked at since not everybody in the dataset had the opportunity to realize the full 12, 24, 36, and 48 months of service respectively. As we progressed to greater number of months served, our data became more and more restricted. For example, the analysis we conducted on availability differences for months 37-48 only included cohorts from FY 2010 through FY 2013, whereas availability differences for months 1-12 included cohorts from FY 2010 through FY 2016. Thus, changes in availability that may have taken place between earlier cohorts and later cohorts may not be captured in the averages of availability for later in the population's first term of service.

Using the re-shaped data, we explored the differences in deployability between males and females during their first term of service. Furthermore, we examined the differences in deployability for females across differing occupational fields during their first term of service.

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## **IV. RESULTS**

The main objective of this study is to examine the implications of altering the gender composition of the Marine Corps on recruiting and readiness. The first section of this chapter discusses the potential consequences to recruiting and the second section deals with the potential repercussions to readiness.

### **A. RECRUITING IMPLICATIONS**

The average civilian male is 5.2 times more likely to graduate from ITB than the average civilian female. When we estimate the predicted probability of both a civilian female and a civilian male graduating from ITB, the predicted probability for a civilian female was 17% and the predicted probability for a civilian male was 89%. Due to the limitations with the data on run times and pull-ups, the predicted probability is likely biased upward. Additionally, there are likely omitted variables from this model, such as mental aptitude, which overestimate the significance of the included variables. Furthermore, the sample is not necessarily representative of the U.S. population since the data comes from the performance of California's 9th grade students. It is difficult to say how this would bias the estimates without knowing how California's fitness levels compare to the rest of the U.S. Lastly, self-selection may cause an upward bias since Marines that are more likely to graduate from ITB probably choose to go that route, and we use the mean of their run times to calculate the predicted probability. The only downward bias may come from the fact that the data represent individuals that are a few years younger than the population that would be eligible to enlist. Overall, we expect that the predicted probability is positively biased. Despite the existing biases, there is a distinct disparity in the predicted probabilities between the average civilian male and average civilian female.

This method of calculating predicted probabilities may provide a starting point from which we may analyze some costs and benefits of further increasing the Marine Corps' female population. For example, if we accept 17% as the predicted probability of a female from the civilian population graduating from ITB, in order to get an expected value of 1 graduate, nearly 6 females would need to be pumped through ITB. In other words, in order

to get one additional female Marine to pass through ITB, a recruiter faced with the 17% probability of a female graduating may need to recruit around 6 females, whereas the recruiter would only need to recruit around 1-2 males for the same probability of graduating. This would increase costs in terms of recruiting efforts and the cost to train additional recruits. Furthermore, the cost of recruiting a single female versus the cost of recruiting a single male may already be higher due to differences in the propensity to enlist.

## **B. READINESS IMPLICATIONS**

### **1. Availability Differences between Females and Males**

We compare the availability of females and males by looking at the proportion of individuals that were available compared to those that were unavailable, conditional on the individual having made it to that month of service. When we first looked at the rates of availability by looking at the portion of available females and males from the entire population, regardless of whether a part of the population had attrited or not, we saw that females attrite at a higher rate than men, which made their availability rate appear to be even lower. After an individual attrites, he or she continued to be counted in future months. Since this group of individuals grew more rapidly for females, the disparity in availability between men and women grew artificially faster than reality.

For example, before handling attrition throughout the population, females were available 24.89% of the time in the first twelve months and males were available 26.94% of the time in the first twelve months. For months 13-24, the females were available 76.63% of the time and males were available 87.83% of the time. As shown in Table 10, when the population that had attrited was included in the data and continued to grow over time, there was a 2.05% percentage point difference in availability between females and males for the first year and a 11.2% percentage point difference in the second year with males being more available than women in both years.

Table 10. Percentage Point Differences in Availability before and after Handling Attrition

| Availability Based on Total Population |        |        | Availability Based on Retained Population |        |        |
|----------------------------------------|--------|--------|-------------------------------------------|--------|--------|
|                                        | m1-12  | m13-24 |                                           | m1-12  | m13-24 |
| avg % avail females                    | 24.89% | 76.63% | avg % avail females                       | 26.43% | 84.28% |
| avg % avail males                      | 26.94% | 87.83% | avg % avail males                         | 27.99% | 93.66% |
| diff in % avail                        | 2.05%  | 11.20% | diff in % avail                           | 1.56%  | 9.38%  |

When we looked at the availability differences between females and males, conditional on them having made it to that month, we saw that the average percent available in months 1-12 was 26.43% for females and 27.99% for males. In months 13-24, the average percent available was 84.28% for females and 93.66% for males. After excluding the population that attrited from the total population to which we compared the available individuals, there was only a 1.56 and 9.38 percentage point difference as opposed to the 2.05 and 11.2 percentage point difference. To mitigate the exaggerated gap of availability between females and males, we compared the availability between females and males by looking at the portion of individuals that were available compared to those that were unavailable, conditional on them having made it to that month.

Although unwanted attrition may be an important issue in and of itself, we did not want the disparities in attrition to skew the comparisons of availability between females and males in our analyses. Despite the exclusion of the attrited population from the total population to which we compare availability, we find that females still tend to be less available than males over the first four years of service (see Figure 5).

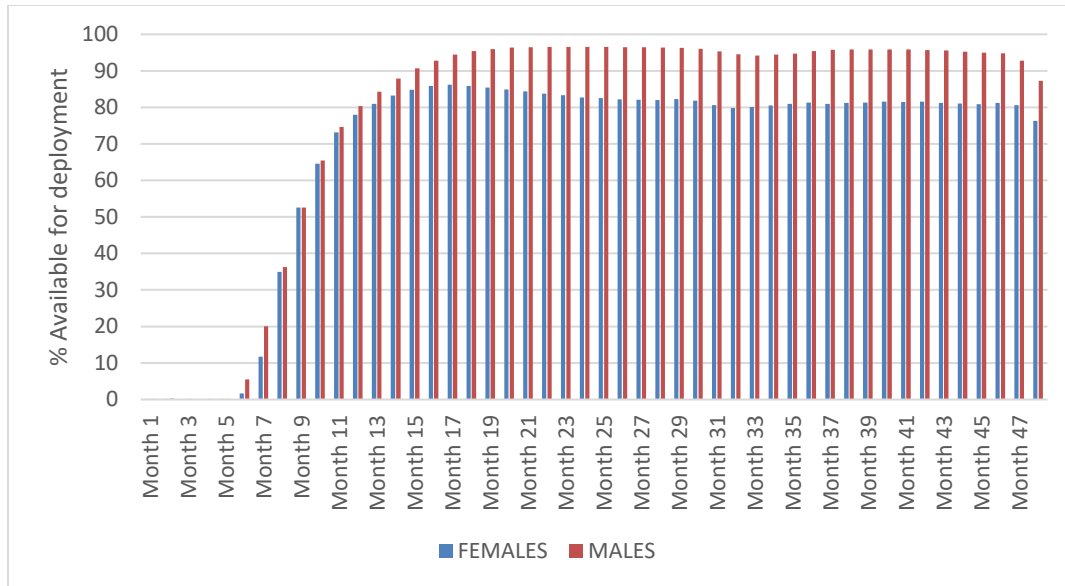


Figure 5. Availability Differences between Females and Males from Months 1-48

**a. Months 1-12**

For the first 12 months of service, the availability of females and males was very similar. The average percent of females that were available was 26.43%. For males, the average percent available was 27.99%. As expected, a small percentage of both males and females were available during these months, most likely due to initial training and females were, on average, slightly less available.

**b. Months 13-24**

During months 13-24, we see a drastic change in availability for both males and females as shown in Figure 6, likely due to individuals having completed their initial training. However, we start to see the differences in availability time between males and females becoming greater. Although excluding the attrited population decreased the disparity of availability between males and females, it is still a marked increase in difference of availability from the first 12 months to the next.

**c. Months 25-36**

From the four time periods that we analyzed, this is where the differences in female and male availability peaked. For months 25-36, the average percent of females between that were available was 81.36% and the average percent of males that were available was 95.57%. From the previous 12 months, the availability for males improved by 1.91 percentage points while the availability for females decreased by 2.93 percentage points.

**d. Months 37-48**

For months 37-48, the average percent of females that were available was 80.79% and the average percent of males that were available was 94.62%. From the previous 12 months, the availability for both males and females decreased, but the decrease was larger for males. Males decreased by .95 percentage points and females decreased by .57 percentage points.

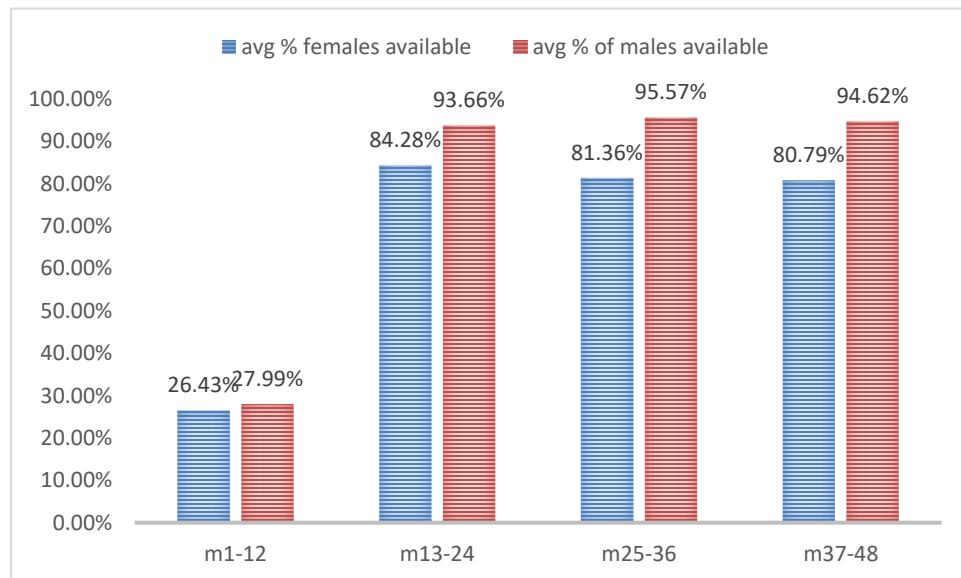


Figure 6. Average Percent of Availability for Females and Males by Yearly Grouping

## 2. Unavailability Breakdown

We find that the top three categories that caused females to be unavailable over the course of the first four years of service were initial entry training, pregnancy, and medical conditions that limited full duty (see Figure 7). For males, the top three categories that caused unavailability over the course of the first four years of service were initial entry training, medical conditions that limited full duty, and PCS (see Figure 8).

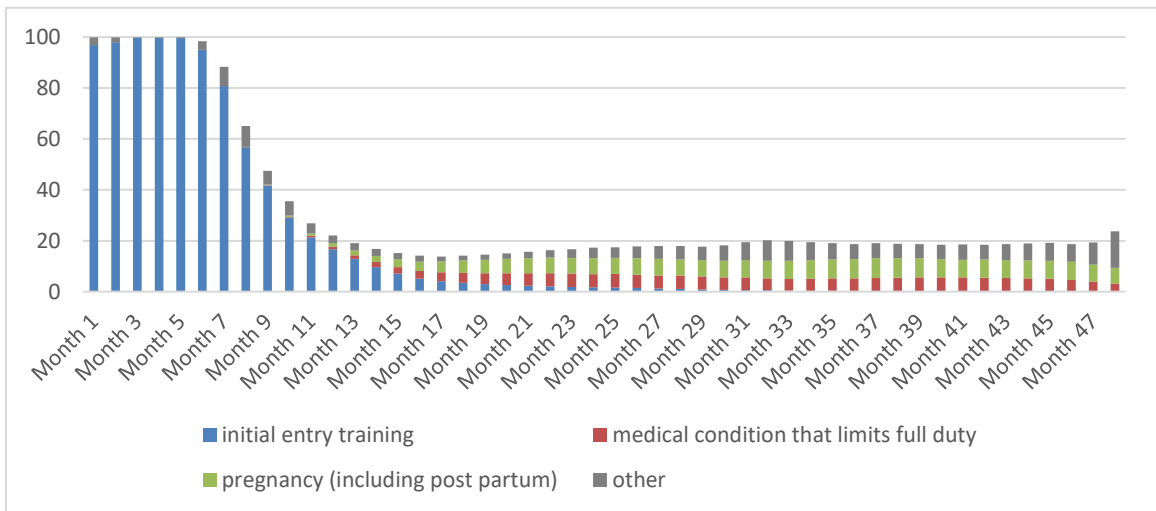


Figure 7. Percent Unavailable for Top 3 Categories for Females

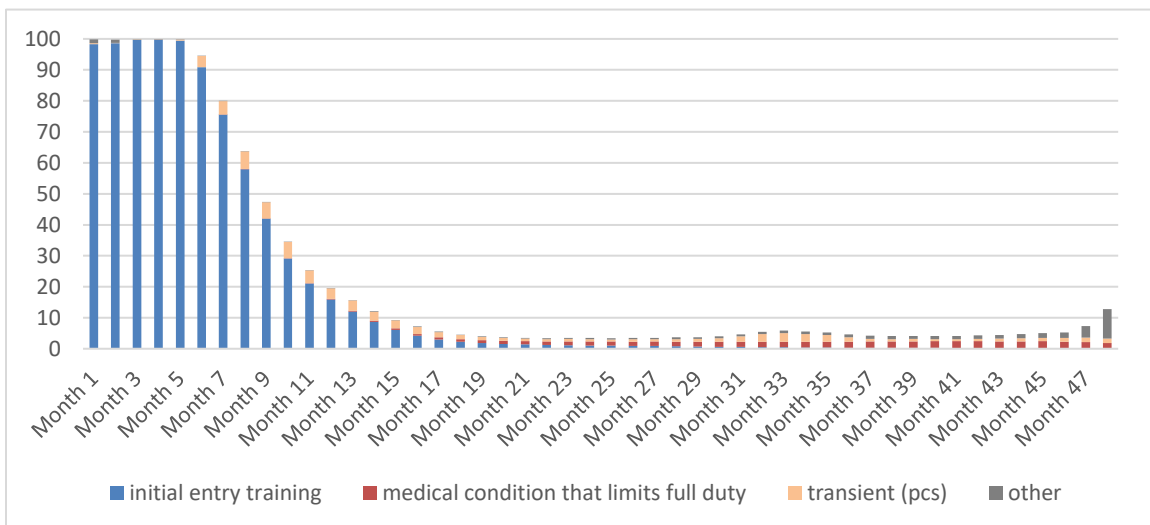


Figure 8. Percent Unavailable for Top 3 Categories for Males

The two categories for females that account for most of the unavailability after initial entry training make up a larger percentage of the total population of females than the two categories for males make up the total population of males. In other words, although 25.51% of the unavailable male population on average is unavailable throughout months 13-24 due to PCS, of the entire male population, the PCS individuals only make up 1.61%. On the other hand, 29.51% of the unavailable female population on average is unavailable throughout months 13-24 due to pregnancy, and the pregnant individuals make up 4.64% of the entire female population. Thus, in the following sections, the percentages of unavailability reflect the portion of the unavailable population that fell into their respective categories so the numbers between males and females should not be compared. Rather, the numbers provide insight as to the magnitude of each category's influence on each gender's non-deployable situations (see Figures 9 and 10).

**a.      *Months 1-12***

For the first twelve months, of the unavailable female population, 94.63%, on average, were not deployable due to initial training. Similarly, of the unavailable male population, 95.84%, on average, were also not deployable due to initial training.

**b.      *Months 13-24***

During months 13-24, the category that contributed most to the unavailability of females was pregnancy. On average, of the unavailable population, 29.51% were not deployable due to pregnancy during the second year of their service. The next two categories that contributed to unavailability were initial entry training and medical conditions that limited full duty. On average, 29.74% were not deployable due to initial entry training, and 24.15% were not deployable due to medical conditions that limited full duty.

For males, most of the unavailability for months 13-24 is still caused by initial entry training. On average, in the second year of service, 58.49% of the unavailable population were not deployable due to initial entry training. The other two categories that significantly contributed to unavailability were PCS and medical conditions that limited full duty. On average, 25.51% of the unavailable population were not deployable due to PCS, and

12.85% of the unavailable population were unavailable due to medical conditions that limited full duty.

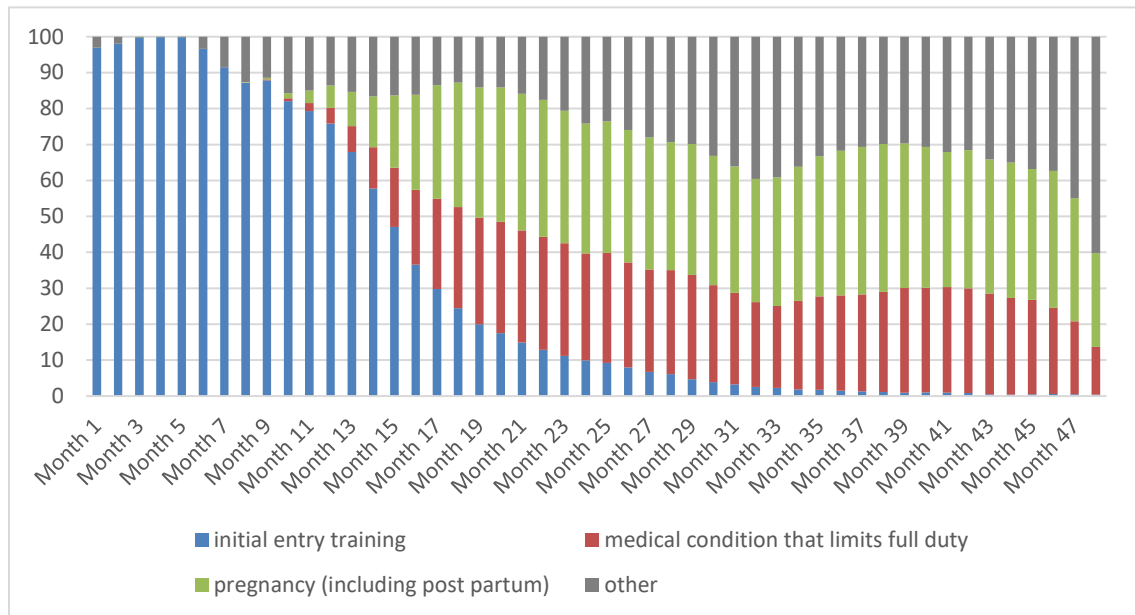


Figure 9. Percent of Unavailability for Top 3 Categories for Females (of the Unavailable Population)

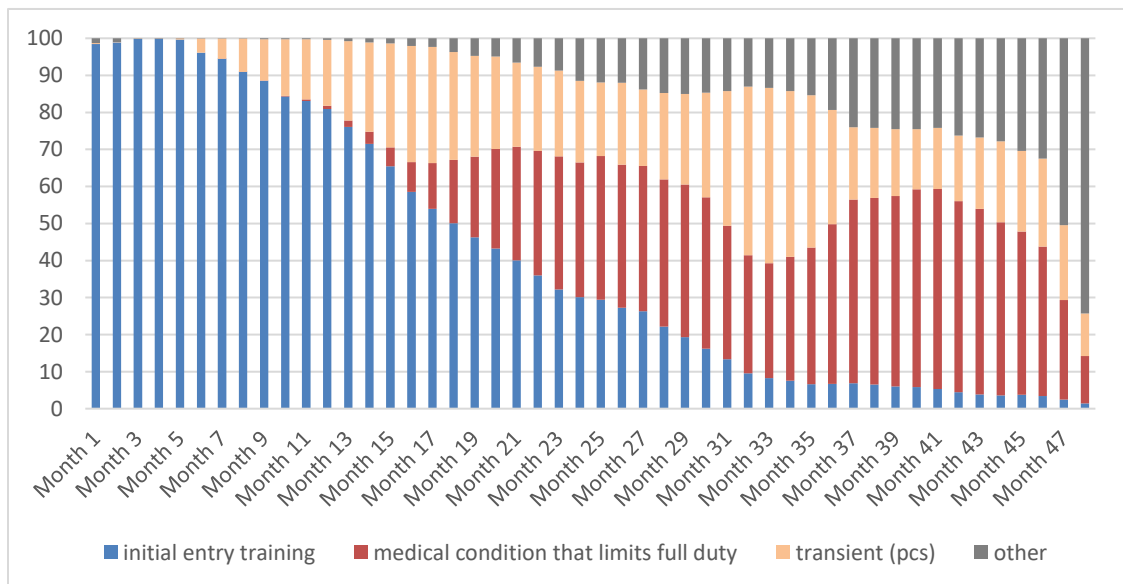


Figure 10. Percent of Unavailability for Top 3 Categories for Males (of the Unavailable Population)

**c.        *Months 25-36***

During months 25-36, pregnancy continued to be the leading factor that contributed to unavailability for females. On average, of the unavailable population, 36.66% were not deployable due to pregnancy; 26.74% were not deployable due to medical conditions; and 16.51 were not deployable due to service discretion.

For males, medical conditions that limited full duty were the main cause of unavailability for months 25-36. On average, of the unavailable population, 37.02% were not deployable due to medical conditions; 33.99% were not deployable due to PCS; and 14.61 were not deployable due to initial entry training.

**d.        *Months 37-48***

During months 37-48, pregnancy is once again the leading cause of unavailability for females. On average, of the unavailable population, 37.05% were not deployable due to pregnancy; 25.57% were not deployable due to medical conditions; and 17.03% were not deployable due to service discretion.

For males, medical conditions are the leading cause of unavailability again. On average, of the unavailable population, 39.23% are not deployable due to medical conditions; 18.04% are not deployable due to PCS; and 17.39% are not deployable due to awaiting administrative separation and expiration of enlistment.

**3.        *Readiness across Occupational Fields***

We find that the top three occupational fields with the highest first term average availability for females had higher representation of females in their community than the bottom three occupational fields with the lowest first term average availability for females. Table 11 shows the occupational fields in order of female density, from lowest to highest, and their respective first-term average availability for the female population. The occupational fields highlighted in orange display the communities that had the lowest first term average availability. These occupational fields had female densities between 6.7-13.73%. The occupational fields highlighted in green display the communities with the highest first term average availability. These occupational fields had female densities

between 15.32-24.81%. We exclude the infantry (03), artillery (08), and tank (18) communities from this analysis because the females in these communities have not had the opportunity to realize a full term of 48 months.

Table 11. First Term Average Availability by Female Density

| OCC_FIELD TITLE                                                | OCC_FIELD | Female Density | First Term Avg Availability |
|----------------------------------------------------------------|-----------|----------------|-----------------------------|
| GROUND ORDNANCE MAINTENANCE                                    | 21        | 2.63           | 69.631875                   |
| GROUND ELECTRONICS MAINTENANCE                                 | 28        | 4.72           | 57.43041667                 |
| AVIATION COMMAND AND CONTROL (C2) ELECTRONICS MAINTENANCE      | 59        | 5.28           | 59.16125                    |
| AIRCRAFT MAINTENANCE (ROTARY-WING)                             | 61        | 5.31           | 67.601875                   |
| AIRCRAFT MAINTENANCE (FIXED-WING)                              | 62        | 6.19           | 68.60875                    |
| ENGINEER, CONSTRUCTION, FACILITIES, AND EQUIPMENT              | 13        | 6.2            | 69.97666667                 |
| PILOTS/NAVAL FLIGHT OFFICERS                                   | 75        | 6.7            | 36.8754375                  |
| INTERMEDIATE AVIONICS MAINTENANCE                              | 64        | 7.54           | 60.808125                   |
| AVIATION ORDNANCE                                              | 65        | 7.73           | 69.49770833                 |
| UTILITIES                                                      | 11        | 7.77           | 69.63375                    |
| MOTOR TRANSPORT                                                | 35        | 8.64           | 69.54104167                 |
| CHEMICAL, BIOLOGICAL, RADIOLOGICAL, AND NUCLEAR (CBRN) DEFENSE | 57        | 8.81           | 63.64666667                 |
| COMMUNICATIONS                                                 | 6         | 9.12           | 66.87125                    |
| NAVIGATION OFFICER/ENLISTED FLIGHT CREWS                       | 73        | 9.4            | 54.83479167                 |
| AIR CONTROL/AIR SUPPORT/ANTIAIR WARFARE/AIR TRAFFIC CONTROL    | 72        | 9.61           | 68.58041667                 |
| ORGANIZATIONAL AVIONICS MAINTENANCE                            | 63        | 10.34          | 62.49979167                 |
| MILITARY POLICE, INVESTIGATIONS, AND CORRECTIONS               | 58        | 10.71          | 68.66166667                 |
| AIRFIELD SERVICES                                              | 70        | 10.93          | 70.55625                    |
| AIRCRAFT MAINTENANCE                                           | 60        | 12.77          | 71.12854167                 |
| SIGNALS INTELLIGENCE/GROUND ELECTRONIC WARFARE                 | 26        | 13.73          | 56.06375                    |
| LOGISTICS                                                      | 4         | 15.1           | 71.41104167                 |
| MUSIC                                                          | 55        | 15.27          | 71.26770833                 |
| MAGTF PLANS                                                    | 5         | 15.32          | 75.19916667                 |
| INTELLIGENCE                                                   | 2         | 15.72          | 66.90895833                 |
| LEGAL SERVICES                                                 | 44        | 17.99          | 70.03104167                 |
| FINANCIAL MANAGEMENT                                           | 34        | 18.19          | 68.99520833                 |
| AMMUNITION AND EXPLOSIVE ORDNANCE DISPOSAL                     | 23        | 18.41          | 72.68166667                 |
| AVIATION LOGISTICS                                             | 66        | 19.69          | 72.16354167                 |
| METEOROLOGY AND OCEANOGRAPHY (METOC)                           | 68        | 19.95          | 57.9225                     |
| FOOD SERVICE                                                   | 33        | 23.84          | 70.08270833                 |
| PERSONNEL AND ADMINISTRATION                                   | 1         | 24.6           | 69.03791667                 |
| SUPPLY CHAIN MATERIAL MANAGEMENT                               | 30        | 24.81          | 72.31291667                 |
| DISTRIBUTION MANAGEMENT                                        | 31        | 27.78          | 72.19833333                 |
| COMMUNICATION STRATEGY & OPERATIONS                            | 45        | 36.65          | 69.52958333                 |

Although there seems to be a correlation between density and availability based off the three highest average availabilities and the three lowest average availabilities and their respective female densities, a line fit to the full data shows that it is not significant at the 5% level. Figure 11 shows a plot of the relationship between female density and the average first term availability of the female population for all of the occupational fields displayed in Table 11. Although there are several low female density occupational fields that appear to have lower average availability, the remainder of the low-density communities have similar average first term availability as the high density communities.

There may be several explanations for the relationship between low female density and low average availability during the first term in some of the occupational fields. First, there is a possibility that the correlation is due to other factors, such as the length of MOS schools. If the MOSs that have longer training periods also tend to be the MOSs with lower density of females, the female density may be capturing the effects of the longer training periods on the first term average availability. Another potential explanation may be what researchers have studied regarding critical mass (see Delus, 2017). Although Delus' study only examines how critical mass of female Marines may affect attrition, the theory in general applies to other human behaviors as well. It is possible that the power of numbers, or lack thereof, may be a contributing factor not only to females' decisions to separate from the Marine Corps, but also to their decisions regarding family planning, health, or any other factors related to their deployability.

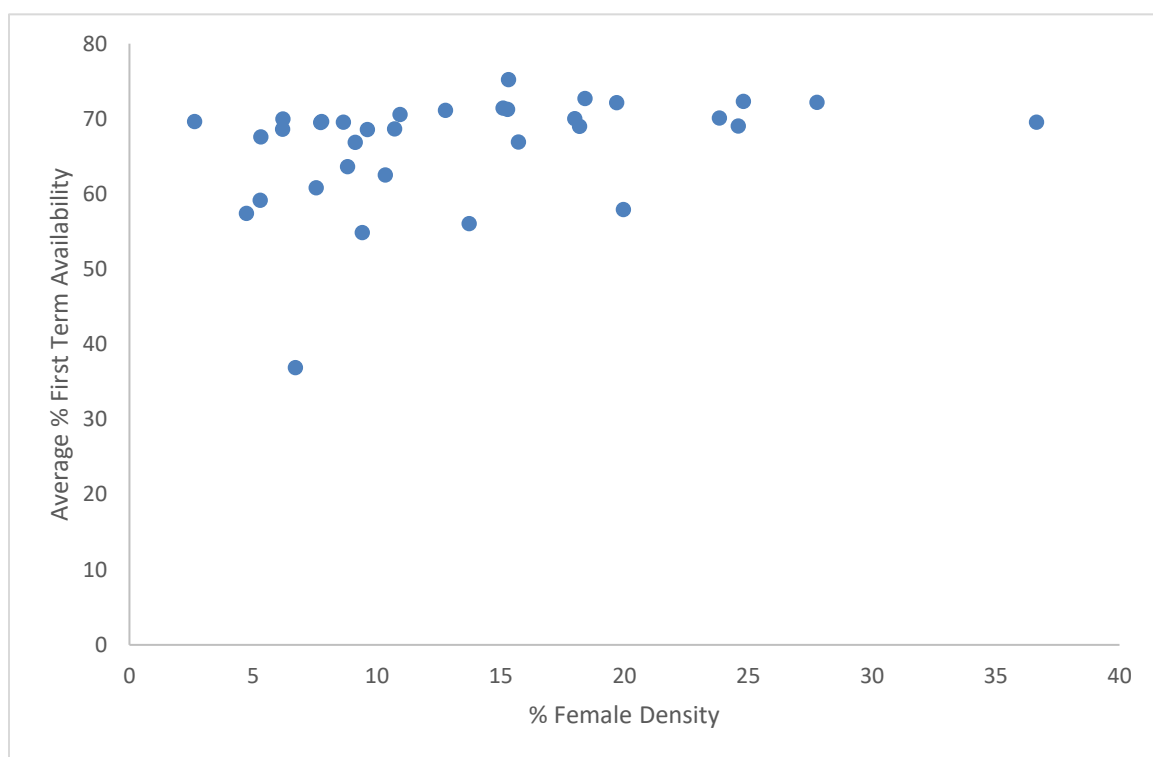


Figure 11. First Term Average Availability by Female Density

Our study explores the implications of altering the gender composition of the Marine Corps on recruiting and readiness. In both facets, our data show that the increase of females may have repercussions on recruiting and readiness that must be considered in analyzing the costs associated with accessing more females. Nevertheless, the costs of increasing the number of females in the Marine Corps may be offset by benefits that are more difficult to quantify, but such benefits must undoubtedly be considered.

## **V. CONCLUSION**

Despite our focus on recruiting and readiness in this study, we must remember that the pursuit of maximizing our combat effectiveness involves many other factors as discussed in Chapter 2. The Marine Corps, as the “firm” in our analogy, must consider how the ratio of males to females may affect our recruiting and readiness, but these are only two of the many factors of production in maximizing output.

### **A. RECRUITING IMPLICATIONS**

We examine the implications of altering the gender composition on recruiting by estimating the predicted probabilities of the average civilian female graduating from ITB in comparison to the average civilian male. Despite the limitations to our data and methodology, it appears that increasing female representation in the Marine Corps, specifically within the combat arms community, may have costly implications on recruiting. With the average civilian male being 5.2 times more likely to graduate from ITB than the average civilian female, the costs of recruiting enough females to reach a success rate that results in increased female representation would also be exacerbated by the costs to train those individuals.

However, this is not necessarily indicative of the costs to recruiting females across all occupational specialties. As discussed in Chapter 2, females will likely self-select into MOSs that will yield their highest utilities, which means that a higher representation of females in the entire Marine Corps does not necessarily mean higher representation in the combat arms MOSs. The information displayed in Table 10 indicates that recruiting efforts for females have already likely increased. The representation of women increased from 8.37% to almost 10% between the FY cohorts of 2010 to 2017. Although the data are not representative of the entire Marine Corps population, this may indicate that there are already shifts in recruiting to meet the 10% goal since the data only includes individuals that have a PEBD of October 2009 or later.

Table 12. Gender Breakdown by Fiscal Year Cohorts

|                | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   |
|----------------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>F Count</b> | 2,289  | 2,360  | 2,437  | 2,658  | 2,597  | 2,562  | 2,871  | 3,003  |
| <b>F %</b>     | 8.37   | 8.03   | 8.12   | 8.45   | 10.32  | 8.92   | 9.69   | 9.8    |
| <b>M Count</b> | 25,043 | 27,031 | 27,567 | 28,789 | 22,564 | 26,172 | 26,746 | 27,635 |
| <b>M %</b>     | 91.63  | 91.97  | 91.88  | 91.55  | 89.68  | 91.08  | 90.31  | 90.2   |

## B. READINESS IMPLICATIONS

We examine the implications of altering the gender composition on readiness by comparing differences in availability between males and females and then further looking at availability differences for females across occupational fields. We find that during the first term of service, on average, females are less deployable than males, with the differences peaking during months 25-36. The major causes of a female's non-deployability, aside from initial entry training, are pregnancy and medical conditions that prohibit full duty, whereas major causes for a male's non-deployability, aside from initial training, are medical conditions that prohibited full duty and PCS. Pregnancy and medical conditions prohibiting full duty make up a larger part of the female population than medical conditions prohibiting full duty and PCS make up the male population. The other non-deployable categories make up very small portions of the non-deployable populations for both males and females.

The occupational field analysis indicates that the density of females is not significantly correlated with the overall readiness of the female population within their respective communities. However, the top three occupational fields with the highest first term average availability for females have higher representation of females in their community than the bottom three occupational fields with the lowest first term average availability for females.

## C. RECOMMENDATIONS

The results of the analysis on availability differences between males and females show that pregnancy is a leading factor contributing to unavailability for females during

their first four years of service. It is clear that family planning at the individual level can play a big role in the overall readiness of the force. Although the Marine Corps should not dictate a Marine's reproductive choices, there may be opportunities for the Marine Corps to facilitate family planning that is both beneficial for the health of the force and also in alignment with a female Marine's interests. For example, there may be female Marines who are willing to hold off on starting a family in order to remain available for upcoming deployments. However, the decision to hold off may involve incredibly difficult and expensive procedures such as mature oocyte cryopreservation. If processes such as these are either unavailable for females or difficult to navigate, individuals are less likely to consider these types of measures. Although mature oocyte cryopreservation may be more relevant for the female population that is further along in their careers, and not in their first term of service, this discussion is still relevant for the overall female population's readiness and even possibly retention.

The results of the analysis on availability differences between females across MOSs are not statistically significant, but there may still be room for discussion regarding the density of females in an MOS and its effect on their availability. Having more female representation within a community will likely foster opportunities for mentorship for young, female Marines related to female-oriented matters, which may positively contribute to their readiness. For example, if a young, female Marine gets pregnant, and she has a difficult delivery, the recovery period post-partum may be elongated by a lack of knowledge and support. She may feel pressured to return to full-duty sooner than required and further aggravate her physical condition, which may return her to limited duty again. In contrast, a female Marine who is surrounded by other Marines that have gone through similar experiences or are understanding of her situation will likely encourage her to focus on self-care during the post-partum period, and provide her with valuable resources that may help speed up the recovery process. Although this is only a hypothetical example of how the proportion of female population in an occupational field may affect readiness levels, it is likely that if a female Marine is a part of a community where she has more support in female-oriented matters, she will likely have more resources to make better-informed decisions that may contribute to her readiness.

#### **D. FUTURE STUDIES**

Further research into how gender composition may affect the Marine Corps, both on the recruiting and readiness fronts, would be valuable in getting closer to answering the impossible question about the ideal gender composition. However, with the end state of conducting a cost benefit analysis, we recommend further studies not only on physical ability and deployability differences between females and males, but also differences in cognitive abilities, adaptability, leadership, and other factors that may contribute to combat effectiveness. This study focused on the costs of increasing female representation in the Marine Corps, but similar studies focusing on the benefits would be necessary for a complete analysis. Looking at qualities such as the ability to balance team dynamics, high pain tolerance, inclination for burden sharing, and decision-making through exhaustion as examined by Witte (1996) may provide insight as to the advantages of heterogeneous teams.

Furthermore, the data shows that the attrition rate is higher for females than males during the first four years of their service. Although that was not the focus of this study, the costs of attrition must also be considered in a complete analysis on the costs and benefits of altering the gender composition of the Marine Corps.

Lastly, an analysis similar to the “street to fleet” part of this study, which examines the predicted probabilities of the average civilian male and female graduating from ITB, would be useful in examining the predicted probabilities of the average civilian male and female graduating from MCT. This may provide a more relevant estimate considering that a higher proportion of females will likely be found in non-combat arms MOSs in the immediate future.

## APPENDIX A. HEIGHT DATA

Table 8. Height in inches for children and adolescents aged 2–19 years and number of examined persons, mean, standard error of the mean, and selected percentiles, by sex and age: United States, 2011–2014

| Sex and age <sup>†</sup> | Number of<br>examined<br>persons | Mean   | Standard<br>error of<br>the mean | Percentile |      |      |      |      |      |      |      |      |
|--------------------------|----------------------------------|--------|----------------------------------|------------|------|------|------|------|------|------|------|------|
|                          |                                  |        |                                  | 5th        | 10th | 15th | 25th | 50th | 75th | 85th | 90th | 95th |
| Male                     |                                  | Inches |                                  |            |      |      |      |      |      |      |      |      |
| 2 years                  | 220                              | 36.3   | 0.18                             | 33.5       | 34.1 | 34.5 | 34.9 | 36.4 | 37.6 | 38.0 | 38.4 | †    |
| 3 years                  | 225                              | 39.0   | 0.14                             | 36.0       | 36.5 | 37.3 | 37.6 | 39.0 | 40.1 | 40.9 | 41.2 | 42.4 |
| 4 years                  | 229                              | 42.0   | 0.15                             | 39.1       | 39.7 | 40.3 | 40.5 | 41.9 | 43.4 | 43.9 | 44.2 | 44.9 |
| 5 years                  | 195                              | 44.8   | 0.21                             | 41.6       | 42.2 | 42.7 | 43.6 | 44.5 | 46.3 | 47.1 | 47.6 | 48.0 |
| 6 years                  | 246                              | 47.2   | 0.19                             | 44.1       | 44.6 | 45.1 | 45.6 | 47.3 | 48.6 | 49.5 | 49.8 | 50.9 |
| 7 years                  | 231                              | 49.8   | 0.19                             | 45.7       | 46.7 | 47.2 | 48.0 | 49.9 | 51.5 | 52.4 | 52.7 | 53.8 |
| 8 years                  | 227                              | 51.9   | 0.24                             | 47.2       | 48.7 | 49.2 | 50.2 | 51.7 | 53.4 | 54.8 | 55.4 | 56.1 |
| 9 years                  | 218                              | 53.7   | 0.23                             | 50.0       | 50.3 | 51.4 | 52.1 | 53.4 | 55.3 | 56.4 | 57.1 | †    |
| 10 years                 | 207                              | 56.3   | 0.26                             | 51.4       | 52.5 | 53.3 | 54.3 | 56.3 | 58.0 | 58.7 | 59.2 | 60.3 |
| 11 years                 | 186                              | 59.2   | 0.31                             | 54.5       | 55.1 | 55.9 | 56.8 | 58.7 | 61.2 | 63.0 | 63.9 | †    |
| 12 years                 | 181                              | 61.4   | 0.31                             | 56.4       | 57.4 | 58.1 | 59.3 | 61.2 | 63.5 | 64.4 | 64.9 | 66.3 |
| 13 years                 | 175                              | 64.3   | 0.32                             | 57.8       | 59.7 | 60.4 | 62.1 | 64.5 | 66.4 | 67.8 | 68.3 | 69.1 |
| 14 years                 | 184                              | 66.7   | 0.31                             | 60.5       | 62.7 | 63.8 | 65.1 | 66.5 | 68.5 | 70.2 | 70.7 | †    |
| 15 years                 | 156                              | 68.3   | 0.28                             | 64.2       | 64.6 | 65.1 | 66.3 | 68.4 | 69.6 | 70.8 | 71.5 | 73.6 |
| 16 years                 | 178                              | 68.5   | 0.24                             | 64.0       | 65.4 | 66.0 | 66.9 | 68.7 | 69.9 | 70.7 | 71.8 | 73.0 |
| 17 years                 | 147                              | 68.9   | 0.40                             | 63.6       | 64.6 | 65.3 | 66.4 | 68.8 | 71.0 | 72.6 | 73.9 | 75.0 |
| 18 years                 | 160                              | 69.1   | 0.33                             | 64.1       | 64.8 | 65.7 | 66.9 | 69.0 | 71.3 | 72.2 | 73.0 | 73.6 |
| 19 years                 | 144                              | 69.4   | 0.44                             | 64.0       | 65.4 | 66.4 | 67.2 | 69.3 | 71.3 | 72.2 | 73.0 | †    |
| Female                   |                                  |        |                                  |            |      |      |      |      |      |      |      |      |
| 2 years                  | 264                              | 35.4   | 0.11                             | 32.9       | 33.2 | 33.8 | 34.3 | 35.2 | 36.5 | 37.3 | 37.7 | 38.2 |
| 3 years                  | 199                              | 38.6   | 0.13                             | 35.8       | 36.5 | 37.2 | 37.6 | 38.5 | 39.6 | 40.3 | 40.7 | 41.3 |
| 4 years                  | 206                              | 41.7   | 0.16                             | 38.2       | 39.2 | 39.5 | 40.4 | 41.7 | 42.9 | 43.5 | 44.1 | 44.5 |
| 5 years                  | 178                              | 44.2   | 0.21                             | 40.6       | 41.1 | 41.8 | 42.5 | 44.0 | 45.6 | 46.8 | 47.4 | 48.2 |
| 6 years                  | 216                              | 46.7   | 0.17                             | 43.3       | 44.1 | 44.6 | 45.1 | 46.7 | 48.3 | 49.0 | 49.4 | 50.3 |
| 7 years                  | 211                              | 49.0   | 0.18                             | 45.2       | 46.1 | 46.7 | 47.7 | 48.7 | 50.4 | 51.6 | 52.2 | 53.0 |
| 8 years                  | 197                              | 51.8   | 0.18                             | 47.7       | 48.6 | 49.0 | 50.0 | 51.7 | 53.6 | 54.6 | 55.4 | 56.2 |
| 9 years                  | 206                              | 54.2   | 0.24                             | 50.2       | 51.2 | 51.6 | 52.5 | 54.1 | 55.9 | 56.6 | 57.3 | 58.8 |
| 10 years                 | 187                              | 56.8   | 0.30                             | 51.8       | 53.3 | 54.0 | 54.9 | 56.3 | 58.7 | 59.8 | 61.3 | †    |
| 11 years                 | 230                              | 59.3   | 0.25                             | 53.5       | 55.7 | 56.3 | 57.6 | 59.5 | 61.1 | 61.9 | 63.0 | 63.8 |
| 12 years                 | 166                              | 61.5   | 0.27                             | 56.5       | 57.3 | 58.7 | 59.6 | 61.5 | 63.4 | 64.6 | 65.0 | 65.8 |
| 13 years                 | 160                              | 62.4   | 0.23                             | 58.4       | 59.5 | 60.0 | 61.1 | 62.4 | 63.7 | 64.9 | 65.5 | 66.6 |
| 14 years                 | 169                              | 63.1   | 0.21                             | 59.0       | 59.9 | 60.3 | 61.6 | 63.4 | 64.6 | 65.3 | 66.1 | 66.3 |
| 15 years                 | 150                              | 63.4   | 0.30                             | 58.7       | 59.1 | 60.6 | 61.6 | 63.6 | 65.4 | 66.0 | 66.8 | 67.2 |
| 16 years                 | 187                              | 63.9   | 0.28                             | 60.1       | 60.8 | 61.3 | 61.9 | 63.7 | 65.6 | 66.9 | 67.7 | 68.1 |
| 17 years                 | 140                              | 64.0   | 0.20                             | 60.5       | 60.9 | 61.5 | 62.3 | 64.1 | 65.1 | 66.2 | 67.3 | 68.0 |
| 18 years                 | 154                              | 63.6   | 0.22                             | 59.6       | 60.1 | 61.0 | 61.7 | 63.9 | 65.4 | 66.0 | 66.5 | 67.2 |
| 19 years                 | 152                              | 64.2   | 0.16                             | 60.1       | 60.5 | 61.4 | 62.7 | 64.4 | 66.1 | 66.7 | 67.0 | 67.7 |

† Estimate not shown because the standard error could not be computed due to small sample size.

<sup>†</sup> Age at time of examination.

SOURCE: NCHS, National Health and Nutrition Examination Survey.

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## APPENDIX B. WEIGHT DATA

Table 2. Weight in pounds for children and adolescents from birth through age 19 years and number of examined persons, mean, standard error of the mean, and selected percentiles, by sex and age: United States, 2011–2014

| Sex and age <sup>†</sup> | Number of examined persons | Mean  | Standard error of the mean | Percentile |       |       |       |       |       |       |       |       |
|--------------------------|----------------------------|-------|----------------------------|------------|-------|-------|-------|-------|-------|-------|-------|-------|
|                          |                            |       |                            | 5th        | 10th  | 15th  | 25th  | 50th  | 75th  | 85th  | 90th  | 95th  |
| Male                     |                            |       |                            | Pounds     |       |       |       |       |       |       |       |       |
| Birth–2 months           | 75                         | 11.8  | 0.22                       | 8.7        | 9.5   | 9.7   | 10.3  | 11.7  | 12.9  | 14.0  | 14.4  | 14.8  |
| 3–5 months               | 90                         | 16.1  | 0.27                       | 12.8       | 13.2  | 13.7  | 14.3  | 16.0  | 17.7  | 18.1  | 19.1  | 19.5  |
| 6–8 months               | 103                        | 18.7  | 0.27                       | 15.2       | 15.8  | 16.3  | 16.9  | 18.5  | 20.2  | 21.1  | 21.4  | 22.2  |
| 9–11 months              | 97                         | 21.5  | 0.36                       | 16.9       | 17.7  | 18.3  | 19.2  | 21.0  | 23.3  | 24.8  | 25.2  | 26.0  |
| 1 year                   | 240                        | 25.2  | 0.22                       | 20.4       | 21.3  | 22.3  | 23.0  | 24.9  | 26.5  | 28.7  | 29.2  | 30.7  |
| 2 years                  | 258                        | 31.3  | 0.30                       | 25.3       | 26.2  | 27.3  | 28.6  | 30.8  | 33.0  | 35.2  | 36.6  | 38.7  |
| 3 years                  | 234                        | 35.3  | 0.34                       | 29.4       | 30.3  | 31.2  | 32.4  | 34.6  | 37.3  | 39.9  | 40.3  | 42.2  |
| 4 years                  | 230                        | 40.8  | 0.39                       | 32.1       | 33.8  | 34.4  | 36.1  | 39.8  | 43.9  | 45.6  | 47.6  | 52.8  |
| 5 years                  | 195                        | 46.6  | 0.87                       | 37.2       | 38.6  | 40.1  | 41.5  | 44.4  | 50.9  | 53.6  | 56.0  | 64.2  |
| 6 years                  | 247                        | 52.8  | 0.85                       | 40.3       | 42.1  | 44.3  | 46.3  | 50.8  | 56.8  | 60.5  | 63.4  | 71.7  |
| 7 years                  | 231                        | 61.9  | 1.15                       | 45.0       | 47.9  | 48.3  | 51.3  | 57.4  | 66.4  | 74.4  | 85.8  | 93.6  |
| 8 years                  | 228                        | 69.4  | 1.27                       | 47.8       | 50.7  | 53.2  | 57.2  | 65.5  | 77.2  | 83.7  | 88.3  | 102.3 |
| 9 years                  | 218                        | 74.4  | 1.52                       | 51.4       | 55.3  | 57.1  | 62.1  | 70.2  | 79.9  | 92.6  | 101.9 | 111.1 |
| 10 years                 | 207                        | 88.7  | 2.76                       | 58.6       | 63.4  | 67.9  | 70.8  | 80.5  | 100.9 | 111.4 | 119.3 | 138.5 |
| 11 years                 | 186                        | 107.0 | 3.07                       | 68.2       | 73.4  | 78.0  | 83.8  | 100.9 | 122.7 | 140.1 | 157.4 | 167.8 |
| 12 years                 | 181                        | 111.6 | 3.17                       | 73.6       | 79.3  | 82.2  | 90.9  | 105.0 | 121.1 | 141.3 | 154.7 | 175.9 |
| 13 years                 | 175                        | 133.9 | 3.61                       | 87.8       | 92.1  | 96.1  | 107.1 | 125.1 | 149.2 | 166.0 | 184.9 | 207.0 |
| 14 years                 | 184                        | 145.2 | 4.03                       | 96.7       | 104.7 | 113.3 | 118.9 | 135.4 | 163.1 | 185.5 | 198.1 | 223.6 |
| 15 years                 | 156                        | 157.3 | 4.20                       | 104.0      | 113.7 | 118.1 | 127.3 | 144.5 | 182.1 | 186.9 | 207.7 | 243.2 |
| 16 years                 | 178                        | 164.1 | 2.67                       | 116.0      | 122.7 | 126.7 | 135.1 | 151.4 | 185.7 | 198.9 | 211.8 | 243.2 |
| 17 years                 | 147                        | 165.5 | 4.58                       | 115.5      | 124.9 | 130.0 | 136.1 | 156.8 | 177.8 | 201.7 | 219.6 | 251.7 |
| 18 years                 | 160                        | 179.4 | 7.09                       | 118.9      | 127.4 | 132.3 | 145.3 | 168.5 | 193.6 | 221.1 | 237.6 | †     |
| 19 years                 | 144                        | 174.0 | 4.95                       | 120.2      | 122.8 | 131.3 | 140.8 | 162.5 | 192.5 | 212.3 | 249.3 | †     |
| Female                   |                            |       |                            |            |       |       |       |       |       |       |       |       |
| Birth–2 months           | 72                         | 10.6  | 0.18                       | 8.2        | 8.6   | 8.9   | 9.5   | 10.4  | 11.2  | 11.9  | 12.7  | †     |
| 3–5 months               | 104                        | 14.9  | 0.26                       | 11.3       | 11.9  | 12.3  | 13.4  | 14.7  | 16.4  | 17.2  | 17.4  | 18.1  |
| 6–8 months               | 91                         | 17.7  | 0.26                       | 13.6       | 14.7  | 14.9  | 16.1  | 17.2  | 18.8  | 19.5  | 20.3  | †     |
| 9–11 months              | 104                        | 20.4  | 0.36                       | 15.6       | 17.0  | 17.5  | 18.4  | 20.1  | 22.3  | 23.1  | 23.3  | 25.3  |
| 1 year                   | 224                        | 24.6  | 0.30                       | 18.7       | 20.0  | 20.9  | 21.7  | 24.4  | 26.9  | 28.3  | 29.3  | 30.6  |
| 2 years                  | 293                        | 29.3  | 0.26                       | 23.6       | 24.7  | 25.0  | 26.3  | 28.8  | 31.5  | 33.1  | 34.0  | 36.0  |
| 3 years                  | 201                        | 34.5  | 0.49                       | 28.1       | 28.8  | 29.9  | 31.3  | 33.4  | 36.3  | 38.6  | 41.2  | 42.8  |
| 4 years                  | 206                        | 40.3  | 0.62                       | 30.7       | 31.7  | 32.8  | 35.0  | 39.5  | 43.6  | 45.3  | 47.2  | 56.0  |
| 5 years                  | 179                        | 45.0  | 0.74                       | 33.7       | 35.2  | 36.6  | 39.5  | 43.8  | 48.0  | 52.6  | 54.3  | 61.3  |
| 6 years                  | 216                        | 52.4  | 1.05                       | 38.2       | 39.2  | 41.1  | 44.4  | 49.0  | 58.4  | 64.8  | 67.8  | 73.7  |
| 7 years                  | 211                        | 58.7  | 1.38                       | 42.4       | 43.8  | 45.6  | 48.0  | 53.9  | 64.9  | 74.1  | 80.2  | 89.7  |
| 8 years                  | 197                        | 69.9  | 1.37                       | 49.7       | 51.4  | 52.5  | 56.0  | 63.3  | 78.1  | 86.1  | 94.8  | 102.0 |
| 9 years                  | 206                        | 82.7  | 1.90                       | 54.9       | 58.6  | 59.9  | 64.4  | 75.5  | 93.0  | 106.2 | 112.9 | 129.4 |
| 10 years                 | 187                        | 90.9  | 2.80                       | 56.5       | 61.1  | 65.3  | 72.8  | 85.3  | 104.2 | 114.4 | 126.3 | 139.0 |
| 11 years                 | 230                        | 104.5 | 2.58                       | 66.2       | 73.4  | 76.4  | 83.4  | 97.0  | 119.2 | 131.1 | 142.8 | 167.0 |
| 12 years                 | 166                        | 122.9 | 3.61                       | 76.3       | 83.6  | 88.5  | 95.2  | 112.2 | 144.8 | 159.5 | 171.3 | 199.9 |
| 13 years                 | 160                        | 122.4 | 3.25                       | 85.1       | 90.3  | 95.7  | 100.1 | 113.2 | 135.2 | 156.6 | 170.7 | 172.3 |
| 14 years                 | 169                        | 131.4 | 3.35                       | 93.7       | 99.5  | 104.1 | 109.9 | 118.5 | 145.9 | 165.1 | 179.4 | 187.7 |
| 15 years                 | 150                        | 141.7 | 5.50                       | 96.3       | 103.8 | 108.8 | 115.2 | 128.1 | 158.9 | 181.0 | 195.4 | †     |
| 16 years                 | 187                        | 143.3 | 5.73                       | 100.9      | 103.5 | 107.8 | 112.1 | 132.3 | 155.0 | 184.6 | 210.1 | †     |
| 17 years                 | 139                        | 148.5 | 4.11                       | 103.8      | 111.2 | 113.2 | 118.1 | 133.8 | 170.9 | 189.0 | 199.6 | 239.7 |
| 18 years                 | 154                        | 148.2 | 5.72                       | 99.1       | 105.3 | 113.1 | 119.6 | 137.0 | 160.2 | 180.5 | 201.0 | †     |
| 19 years                 | 152                        | 150.9 | 4.77                       | 97.5       | 101.4 | 109.6 | 119.6 | 137.9 | 174.1 | 188.5 | 220.5 | 249.9 |

† Estimate not shown because the standard error could not be computed due to small sample size.

<sup>1</sup> Age at time of examination.

NOTE: Data exclude pregnant females.

SOURCE: NHES, National Health and Nutrition Examination Survey.

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