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*Form Approved
OMB No. 0704-0188*

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1. REPORT DATE (DD-MM-YYYY) 05 06 2020	2. REPORT TYPE Master of Military Studies (MMS) thesis	3. DATES COVERED (From - To) AY 2019-2020
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4. TITLE AND SUBTITLE CAPITALIZING ON TESTOSTERONE REPLACEMENT THERAPY FOR THE GROUND COMBAT ELEMENT	5a. CONTRACT NUMBER N/A
	5b. GRANT NUMBER N/A
	5c. PROGRAM ELEMENT NUMBER N/A

6. AUTHOR(S) Unkle, Adam S (Major)	5d. PROJECT NUMBER N/A
	5e. TASK NUMBER N/A
	5f. WORK UNIT NUMBER N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) USMC Command and Staff College Marine Corps University 2076 South Street Quantico, VA 22134-5068	8. PERFORMING ORGANIZATION REPORT NUMBER N/A
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9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S) N/A

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
TRT is shown to create physiological improvements that would be beneficial to Marines, particularly in the GCE. Increase of lean muscle mass, increase of bone mineral density and a reduction of injuries are all observed effects with this treatment. Subject matter experts agree that TRT could be beneficial to GCE Marines for these reasons. All documented effects of TRT would certainly improve HP optimization and may lead to greater mission accomplishment. Although there is a lack of research in the application of TRT in military populations, this should not dissuade the USMC from exploring TRT's potentially groundbreaking advancement of HP optimization. The USMC should invest in TRT utilization and research to provide its Marines with every possible advantage heading into the next peer-to-peer conflict.

15. SUBJECT TERMS
Hormones, Human Performance, Testosterone, GCE, TRT, Steroids

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			USMC Command and Staff College
Unclass	Unclass	Unclass	UU		19b. TELEPHONE NUMBER (Include area code) (703) 784-3330 (Admin Office)

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MASTER OF MILITARY STUDIES

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SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF MILITARY STUDIES

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Executive Summary

Title: Capitalizing on Testosterone Replacement Therapy for the Ground Combat Element

Author: Major Adam S. Unkle, United States Marine Corps

Thesis: The United States Marine Corps (USMC) should capitalize on the utility of testosterone replacement therapy (TRT) to complement existing investments in human performance (HP) optimization.

Discussion: Over the last four years the USMC has taken a few steps towards optimizing HP, but more work needs to be done. Creation of the Force Fitness Instructor (FFI) program and the expansion of the Sports Medicine and Injury Prevention (SMIP) program are good examples of USMC investment towards optimizing HP. Even with these investments, however, there are other interventions to improve HP that the USMC is not exploring. Specifically, a treatment already widely utilized in the civilian sector known as testosterone replacement therapy (TRT) could be leveraged by the USMC to contribute towards the HP optimization of older populations.

Conclusion: TRT is shown to create physiological improvements that would be beneficial to Marines, particularly in the GCE. Increase of lean muscle mass, increase of bone mineral density and a reduction of injuries are all observed effects with this treatment. Subject matter experts agree that TRT could be beneficial to GCE Marines for these reasons. All documented effects of TRT would certainly improve HP optimization and may lead to greater mission accomplishment. Although there is a lack of research in the application of TRT in military populations, this should not dissuade the USMC from exploring TRT's potentially groundbreaking advancement of HP optimization. The USMC should invest in TRT utilization and research to provide its Marines with every possible advantage heading into the next peer-to-peer conflict.

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Introduction:

Fitness is a cornerstone of the United States Marine Corp (USMC), and the current and previous Commandants have stressed its importance. These leaders correctly identify that Marines need to care not just about being faster and stronger, but also need to focus on injury prevention and cognitive performance, all of which taken together are best described as human performance (HP) optimization.

The directed focus on HP is sound guidance given the high injury rates of Marines and the natural decline in physical performance as Marines age. A data analysis conducted by Headquarters Marine Corps Force Preservation Division (G-10) shows that in fiscal year (FY) 2017 over 15,000 Marines (7% of the total force) were diagnosed with a musculoskeletal injury (MSKI) which contributed to approximately 7,200 active-duty Marines placed on limited duty each month, thus making them combat ineffective. MSKIs in FY17 also accounted for 27% of all non-end of active service (EAS) separations (8,821 Marines) which cost the USMC over \$500 million dollars in training costs.¹ The problem only becomes more acute as careers progress.

Areas of HP such as aerobic capacity, bone density, and joint mobility begin to decline at the age of 30 and continue to get worse.² This is significant because there are over 34,000 active-duty Marines over the age of 30, and a predominance of this population is USMC leadership comprised of Officers and Staff Non-Commissioned Officers.³ Specifically within the physically demanding military occupational specialties (MOS) of the ground combat element (GCE), there are over 8,000 Marine leaders over 30 years old. Optimizing HP of this older population should be a focus for the USMC to improve its cadre of senior leaders' longevity and continued service.

Over the last four years the USMC has taken a few steps towards optimizing HP,⁴ but more work needs to be done. Creation of the Force Fitness Instructor (FFI) program and the expansion of the Sports Medicine and Injury Prevention (SMIP) program are good examples of USMC investment towards optimizing HP. Even with these investments, however, there are other interventions to improve HP that the USMC is not exploring.

Specifically, a treatment already widely utilized in the civilian sector known as testosterone replacement therapy (TRT) could be leveraged by the USMC to contribute towards the HP optimization of older populations. This treatment in the civilian sector demonstrates the ability to increase bone density, lean-muscle mass, recovery speed, and overall physical wellness.⁵ Therefore, TRT can influence all areas of HP optimization. TRT should not be thought of as an easy solution to solve all the USMC's HP problems, and investments in existing HP programs should continue. As the USMC continues to invest in HP optimization, however, it should not overlook TRT but instead explore its utility, capitalize on its benefits, and complement existing USMC investments in HP optimization.

This paper proceeds with a literature review that examines the state of HP optimization in the USMC, provides a lay description of hormones and testosterone, examines the benefits and risks of TRT, and discusses current gaps in literature. Next, it discusses interviews with subject matter experts conducted by the author on the potential for the USMC to utilize TRT. Then, it makes recommendations for future research and introducing these treatments into the Marine Corps. It concludes with the perceived roadblocks to introducing these treatments.

Literature Review:***Human performance in the USMC***

The USMC has taken several recent actions to emphasize HP optimization. In September 2016, then-Commandant Robert Neller declared the goal of the USMC's Physical Fitness Program (MCPFP) was to optimize mental and physical performance, and he ordered the centerpiece of the MCPFP to be Force Fitness Instructors (FFI) whose aim is to be a subject matter expert to the commander on physical fitness and injury prevention. He also ordered Training and Education Command (TECOM) to create a MCPFP that takes a holistic approach to fitness by incorporating modern technology, sports medicine, and all existing organic fitness capabilities such as Semper Fit.⁶ Shortly after, the Commanding General of Marine Corps Combat Development Command created the framework of the FFI and of Force Fitness Division (FFD)⁷ as a dedicated group with the sole purpose of improving the holistic fitness of Marines.

In late 2018, FFD (renamed to Human Performance Division in April 2020)⁸ released multiple Marine Corps Orders (MCO) advocating for the optimization of physical fitness through smart and balanced training with a focus on injury prevention.⁹ These Orders are important because prior to the release of MCO 6100.14, the only USMC Order that addressed physical fitness was the MCO detailing the Physical Fitness Test and Combat Fitness Test requirements. Codification of the requirements listed in these Orders enables the Deputy Commandants to start resourcing efforts towards optimizing HP.

Prior to the creation of these policies, the Marine Corps invested in the Sports Medicine Injury Prevention (SMIP) program within TECOM, and in 2017, the CMC ordered the expansion of the SMIP program to the operating force. The cornerstone of the SMIP program is civilian

athletic trainers who are trained medical professionals, with bachelors and often master's degrees, and are certified through the National Athletic Trainer's Association. They are precisely the same caliber of athletic trainers seen in professional and college sports organizations. The intent of the SMIP program is to have these athletic trainers at every regiment and group throughout the USMC as full-time personnel¹⁰ with the aim to increase physical readiness by reducing MSKIs. FFD spent the next two years planning, coordinating with the operating force, and hiring these athletic trainers.

The arrival of athletic trainers at regiments and groups occurred in 2019 and is still ongoing in 2021. Due to their limited time within operational units, the effects of the SMIP program have not been compiled by the USMC into detailed research yet. There is anecdotal evidence from Marines and their commanders that the SMIP program is having positive effects. Marine commanders from both air and ground elements praise their athletic trainers and the positive effects they have on their units.¹¹ More research must be completed to examine if the introduction of these programs and the steps taken by the USMC to improve HP has been enough to significantly reduce MSKIs.

While the creation of FFD, the FFI program, and expansion of the SMIP program may help to optimize HP and limit MSKIs, introducing TRT in certain Marine populations may also aid towards these goals. Before examining TRT as an option, a basic understanding of testosterone and its benefits is required.

Importance of testosterone

Hormones are molecules created and released as a part of the body's endocrine system and serve multiple functions such as synthesizing protein, increasing cardiovascular output, and

stimulating growth of muscle tissue. Testosterone is a primary anabolic (to build) hormone that contributes directly to muscle tissue growth, bone density, and speed of recovery. Testosterone therefore helps control physical adaptations to stress, which is important to military personnel. While playing multiple complex roles in the entire endocrine system, testosterone (like other hormones), is a focus of hormonal treatment due to its overall effects on body composition.¹²

Testosterone also appears to play an important role in bone mineral density (BMD). Multiple research studies show a heightened risk of bone fracture when BMD is lower.¹³ This is true not just for an elderly population, but younger populations (ages 20-44) as well. More importantly, there is a strong correlation between higher free testosterone levels and an increase in BMD. Young populations treated with testosterone demonstrate an increase in BMD and overall bone health.¹⁴ The effects of testosterone and BMD are important to the USMC, because lower BMD is causally related to an increased risk of MSKIs.

Multiple studies find that lower BMD is associated with an increase in MSKI.¹⁵ In one study, 43% of all participants with bone stress injuries (i.e. stress fracture of the shins) had low BMD scores. The references are important, because the populations they examine (elite athletes including endurance and strength athletes) are representative of military populations. Also, when examining the population with low BMD that had an injury, low total testosterone is also observed. These references support the hypothesis that an increase in testosterone will increase BMD and lead to a lower rate of MSKI.

Another finding regarding testosterone and BMD is examined by a meta-analysis from the Mayo Clinic College of Medicine examining eight trials involving 365 patients and finds a significant increase of lumbar spine BMD, when testosterone hormone therapy is administered. The review also references another meta-analysis, which has the same findings regarding an

increase of lumbar spine BMD associated with testosterone hormone therapy.¹⁶ These findings are of particular interest to the USMC, as GCE Marines often carry heavy loads on foot, which places extraordinary stress on the lumbar spine and lower back. Further, an increase in testosterone has the potential to directly increase the resilience of Marine's musculoskeletal structure responsible for significant weight-bearing.

Some research points to testosterone being the most important biomarker for improving physical performance. A meta-analysis in 2018 reviewed 161 articles involving biomarkers of well-trained adult male athletes to identify the most important biomarkers related to increased physical performance.¹⁷ Across the examined studies articles, 118 individual biomarkers, were identified and examined against an increase in physical performance. The biomarker identified to be the greatest indicator for increased physical performance was the testosterone to cortisol ratio, where a higher level of testosterone equated to an increase in physical performance. This finding is important as it identifies a correlation in trained male athletes between their physical performance and higher levels of testosterone. Although GCE Marines are usually a fit population to begin with, they may potentially increase their physical performance further with high levels of testosterone.

Significant amounts of research correlate high testosterone to increased bone mineral density, reduced MSKIs, and increased physical performance. A method the USMC can use to increase testosterone and capitalize on its advantages is through TRT.

Benefits and Risks of TRT

TRT is a hormonal treatment that utilizes exogenous (synthetic) testosterone given to individuals with low levels of testosterone which are in medically unhealthy ranges. According

to the American Urological Association (AUA), a level of total testosterone in a male should be at least 300 nanograms per deciliter (ng/dl) or greater and an individual with a level below 300ng/dl should be diagnosed with low testosterone.¹⁸ Typically, TRT is administered to males aged 40 and over, and occasionally to males 30 and over who display symptoms associated with low testosterone such as reduced energy, low sex drive, or depression.¹⁹ The treatment can be given via injection, gel, or orally with injection being the most often used method.²⁰

It is important to understand that TRT is not the same thing as normally thought of “steroid” use, or more specifically, abuse of anabolic androgenic steroids (AAS). There are multiple systematic reviews that highlight the adverse effects of AAS abuse,²¹ but other articles clarify the primary differences between TRT and AAS abuse.²² The references site the key differences as: 1) TRT is administered by a certified physician, and AAS’s are taken without medical supervision, 2) TRT is meant to optimize hormone levels where AAS results in a supra-dosage of testosterone, 3) AASs are obtained illegally and often contain multiple unknown compounds that are not held to a standard, whereas TRT is a known and regulated amount of treatment. The references note that with both TRT and AAS, an increase in lean-muscle mass is observed, but AAS has approximately 20% or greater chance of adverse side effects such as depression or mania. This paper explores the use of TRT as a valid military option, not AAS or typically thought of “steroid” abuse.

TRT can be beneficial to the maintenance of lean muscle mass, while in a high-stress environment. A recent study conducted by USAREIM in 2019 shows TRT being utilized for this purpose.²³ Subjects received TRT while undergoing the exact stressors of ranger school (lack of sleep, nutrition, high physical demands) for 28 days. Of note, the group that received TRT, when compared to the placebo control group retained more than five (5) pounds of lean muscle mass.

GCE Marines are often placed in environments of prolonged high-stress periods and could capitalize on TRT's ability to cause retention of lean-muscle mass.

Benefits of TRT are discussed in a position statement from the European Male Aging Study in 2014²⁴ and an article from the University of Health Sciences in 2009.²⁵ These articles examine current research studies of TRT, the risks versus benefits of treatment, and give recommendations based on the authors' findings. A key hypothesis from the first reference is problems from TRT mainly arise from improper proscripting and a lack of consistent monitoring of treatment (i.e. regularly scheduled testing at 3,6, and 12-month intervals). All typically observed benefits of TRT such as increased lean muscle mass, increased bone density, increased libido, and effective sleep are observed in the articles' findings. Other benefits such as improved cognitive function are observed in some research, but findings are limited and are not conclusive at the time of these references publishing.

The two references from the above paragraph also discuss perceived risks of TRT. Some studies raise concerns about risk to cardiovascular safety, but the references find limited reports to confirm this as a valid risk. Also, prominent endocrinology organizations such as the American College of Endocrinology state there is no consistent evidence that TRT has an adverse effect on the cardiovascular system.²⁶ A negative side effect of TRT often touted in popular culture is negative mood effects or mood swings. The references however find that TRT is most often associated with an improvement in mood, and particularly in individuals with depression. More importantly, when TRT is administered to non-depressed males, studies find that there are no negative effects on mood. Overall, the references conclude that TRT therapy has numerous positive effects seen across much of the existing research and any observed negative effects are rare and often uncorroborated by multiple research projects.

Gaps in literature

Although there is much literature published on the topics of testosterone, TRT, and biomarkers of civilian populations, limited literature examines these treatments in a military population. As military members are only prescribed TRT in extraordinary circumstances, such as cancer treatment, there is not a large population of existing military TRT patients to draw from. Until more research projects in a military population are completed, the military will have to draw heavily on the existing research conducted on civilian populations to examine the use of TRT.

Even within the existing literature of TRT in the civilian sector, there exists gaps that the military should be mindful of. For example, there is not much research associated with performance and testosterone. Most research focuses on groups with low testosterone and disease, instead of focusing on already high-performing individuals and identifying their hormone levels. Research that could provide a better understanding of the ideal level of testosterone, which correlates to high physical performance and mission accomplishment, would prove invaluable to the military.

Another key gap of concern to the military is lack of research on hormone replacement therapy in female populations. Because existing literature on TRT focuses almost exclusively on a male population, this paper explores the use of TRT specifically for a male population. More research of female TRT in the civilian sector should be conducted before the military begins to explore TRT on female Marines.

Research:***Subject Matter Expert Interviews***

Because of gaps in research, interviews with SMEs were conducted to better inform this paper. The interviews provide a better understanding of TRT methodologies, the potential utility of TRT in military populations, and what concerns need to be addressed before further exploration of TRT in the USMC. Interviewed subjects were chosen due to their varied backgrounds in the field of human performance and their exposure to TRT during their career.

The list of subjects interviewed include:

Name:	Degree:	Employer:	Billet:
Mark Riebel	Doctor of Physical Therapy (Baylor University, 2017)	United States Navy (USN)	Human Performance Division, Branch Head
Kevin Bernstein	Doctor of Medicine with Sports Medicine Fellowship (Drexel University, 2011)	USN	Primary Care Sports Medicine
Jason Valadao	Doctor of Medicine with Sports Medicine Fellowship (Medical College of Wisconsin, 2014)	USN	Senior Sports Medicine Doctor
Karen Kelly	PhD in Kinesiology (University of Southern California, 2007)	Naval Health Research Center	Senior Researcher
Brad Nindl	PhD in Applied Physiology (Penn State University, 1999)	University of Pittsburg	Director of Neuromuscular Research Lab and Human Performance
Josh Hagen	PhD in Materials Engineering (University of Cincinnati, 2006)	West Virginia University	Director of Human Performance and Innovation

Karl Friedl	PhD in Biology (UC Santa Barbara, 1984)	US Army Research Institute of Environmental Medicine	Senior Research Scientist Performance Physiology
Jamie Fox	Masters of Kinesiology	Government	Human Performance Director

(Table 1: Interview Subjects)

The author chose subjects with a variety of HP backgrounds to gain different perspectives on TRT. Two of the subjects have direct experience with prescribing TRT in military populations.²⁷ Multiple subjects have been investigators on published studies that have examined biomarkers and other human performance metrics.²⁸ Also, each subject has worked directly with military populations to include the Marines, Navy, and Army. Their work within the military includes research, experimentation, and medical practice all focused on optimizing human performance. Given the level of real-world experience all subjects have obtained in the field of human performance, this group should be viewed as contributing subject matter expertise to this paper.

Topics discussed during the interview were: Medical community aversion to TRT, thresholds for prescribing TRT, optimal levels of testosterone for military service members, benefits to increasing testosterone in physically demanding military occupational specialties, population focused use of TRT in the military, and recommendations for future research of TRT.

Aversion to TRT in the Medical Community

All but one interview subject felt there is an aversion in the overall medical community and/or Navy Medicine to the use of TRT or the further exploration of potential TRT benefits.²⁹ Navy medical personnel can be adverse to prescribing TRT for individuals with medically low testosterone due to potentially adverse side effects such as cardiac problems occasionally

witnessed in older populations.³⁰ An explanation of this hesitation to utilize TRT may be the military's perceived culture of risk aversion.³¹ The medical community is perceived as unwilling to explore utilization of TRT from a human performance perspective as Dr. Karen Kelly, a senior researcher at the Naval Health Research Center, points out, "most people in the medical community are risk adverse and cautious."³² Medical professionals' focus regarding low testosterone or other hormones is to treat these issues strictly from a "disease" or "not diseased" perspective.³³ Also, a general misunderstanding of the differences between TRT and anabolic steroid abuse is present in some medical professionals. This misunderstanding may lead professionals to overlook TRT as a potential treatment option as noted by Lieutenant Commander Mark Riebel, a physical therapist in the USN's human performance division, "Because of the negative light placed on AAS, [medical] professionals often just see the abuse of drugs and Navy folks do not see enough of the good effects of TRT."³⁴ However, this misunderstanding is less prevalent within the sports medicine physician community.³⁵

Even amongst professionals who understand that TRT is different from steroid abuse, there are still concerns within the community of the long-term use of TRT. Not enough is currently known about long-term (i.e., 5+ years) effects of TRT in younger populations and this unknown causes some medical professionals to dismiss the prescription of TRT entirely.³⁶ Some physicians are starting to become more positive towards utilization of TRT and Riebel adds that, "attitudes towards TRT from military professionals are starting to change."³⁷ The overall assessment however, is that a larger shift of attitudes in the medical community will have to occur before the military begins to utilize TRT in an organized manner.

Current TRT prescription practices in the Military

Although there is not an official Naval document stating the hormone thresholds for prescribing TRT, there are best practices derived from current research and use of TRT in the civilian sector.³⁸ Based on literature and experience, interview subjects recommended a range of 300-500ng/dl to be ideal with 500 being the high end of normal.³⁹ Just because an individual has less than 300ng/dl does not mean they should automatically be prescribed TRT. There are also person-to-person testosterone variations to consider as noted by LCDR Kevin Bernstein, a sports medicine physician with the USN, "...low threshold for free testosterone will vary a bit from person to person, and there is age-related changes."⁴⁰ LCDR Jason Valadao, a senior sports medicine doctor with the USN, notes that civilian medical insurance will not cover a TRT prescription unless a patient has, "...at least two symptoms (low sex drive, low energy) and two low level tests (less than 250ng/dl) taken under the correct circumstances."⁴¹ This is typically the same practice that Navy medical providers follow when prescribing TRT to military personnel.

Prescription of TRT in military populations occurs only when there is an identified medical need for the treatment and not for the purpose of enhancing human performance.⁴² For example, a military individual with a testosterone level of 320ng/dl would not receive TRT to raise their level towards the more ideal level of 500ng/dl. According to interview subjects, the most ideal range for Marines in physically demanding MOSs is 500ng/dl and potentially as high as 700ng/dl.⁴³ There is some concern of raising levels higher than 500ng/dl as noted by Bernstein, "When you have TRT, you worry about some potential side-effects. Levels over 500 is tied to adverse effects."⁴⁴ Navy medicine's methods for prescribing TRT to military personnel, although consistent with the greater medical community, would have to change to allow focused use of TRT for human performance optimization.

Benefits to increasing testosterone in Marines

All interview subjects agreed that there could be benefits to increasing the levels of testosterone for Marine infantry or other physically demanding MOSs. Riebel states that, “the increase in lean muscle-mass, decrease in fat, increase in physio output can be translated into MOS specific tasks. [TRT] certainly has the potential to be beneficial.”⁴⁵ A key reason TRT could benefit military populations is due to the testosterone loss experienced in a high stress operational environment. Research states that military personnel placed in an environment that causes lack of sleep, poor nutrition, high physio-load, and high mental stress will have a significant drop in testosterone.⁴⁶ This drop in testosterone can lead to a rapid loss in lean muscle mass, decreased energy, and a drop in cognitive performance. The military cannot control or minimize the number of stressors in this scenario, but the military would have the ability to replace lost testosterone and combat the negative effects of its loss.⁴⁷

The benefit of TRT is only recommended however if it can be monitored by certified medical professionals. Also, it was not recommended that TRT be utilized by all military individuals as stated by Kelly, “You do not want to prescribe [TRT] to someone who is totally healthy and fine, and you cannot say everyone across the board needs it.”⁴⁸ Because males under 30 rarely have a natural deficiency of testosterone, military individuals in the age range of 18-29 would be less likely to benefit from TRT. It would be more beneficial for this population to focus on other types of interventions such as increasing sleep, nutrition optimization, and physical training program modifications.⁴⁹

Beyond monitoring levels of total testosterone in military personnel that are prescribed TRT, the military should also look at other biomarkers. Jamie Fox, a human performance director with the US government states, “Look at the biomarkers, they would tell us the story of

what is really going on...once you identify an issue, then you can influence more than just TRT, but all other aspects of performance.”⁵⁰

With the benefits of TRT being well-documented in current literature and interviewed subjects’ positive attitudes towards utilization of TRT, the USMC should explore methods for capitalizing on the benefits of TRT.

Demographic considerations

The USMC should consider how TRT might affect different demographics. Most interviewed subjects agree that the ideal population for TRT would be Marines that are 30 years of age or older. This is recommended because natural levels of testosterone do not often decrease until males are at least 30 years old.⁵¹ It is important to note that approximately 13.8 percent (22,534) of enlisted and 58.1 percent (12,265) of officers in the active-duty USMC are above the age of 30.⁵² Besides age considerations, mission demands should also play a factor. For instance, even an individual who is under 30 years old with good levels of testosterone may see a significant drop due to prolonged periods of high stress. Both age and operational environment warrant consideration as stated by Dr. Brad Nindl, a physiologist at the University of Pittsburg, “also look at younger populations if they are in an austere environment. So, look at age first, and then look at the mission demands.”⁵³

Before exploring TRT use on certain populations, the groups with the highest risk factors would first need to be identified. This brings up a significant gap in current military practice however, because the USMC and other military services do not have a baseline of testosterone or other biomarkers.⁵⁴ The Navy and USMC conduct a blood draw on all personnel annually as part of the physical health assessment (PHA). This annual blood draw checks for HIV and cholesterol

levels but is not paneled for other biomarkers such as testosterone.⁵⁵ Multiple interview subjects strongly recommend that the Navy and USMC start recording biomarkers like testosterone as part of the PHA. Fox adds that, “monitoring biomarkers across time during the PHA should be mandatory. You could see over time why people are starting to drop and intervene when you need to. Biomarkers can tell you a total story.”⁵⁶ If this paneling is started at the beginning of a Marine or Sailors’ career, then the military could easily identify which populations are at risk, what is the age decrement of testosterone, and who truly can benefit from TRT interventions. Identifying the ideal military populations for TRT should be a primary concern before any implementation.

Recommended research efforts

Recommendations from interview subjects regarding military TRT research display multiple similarities with variations concerning length of the study. Almost all interview subjects recommend the purpose of a TRT study should be to identify an increase in mission performance.⁵⁷ Bernstein suggests introducing TRT into the study group and then, “define [performance] and grade Marines during the training cycle to find out who did better. See if you can tie the supplemented group with an increase in performance.”⁵⁸ This could more easily be accomplished in a training and education environment such as the School of Infantry where there are evaluation metrics tied to performance.

Most interview subjects agree the study should measure multiple factors such as levels of sleep, overall mental well-being, rates of MSKI, and levels of stress. Dr. Josh Hagen, an engineer from West Virginia University, highlights the importance of measuring multiple factors, “Maybe [TRT] doesn’t reduce MSKIs but has positive effects in other areas.”⁵⁹ Based on current research, it is likely that introducing TRT in any population would improve levels of sleep and

reduce injuries, but it would be important to monitor the positive affects against any unforeseen negative consequences.

Another common recommendation is the use of a double-blind method of intervention with at least one control group receiving a placebo. A double-blind research study means that both the researchers and the subjects are unaware whether they are receiving the intervention or placebo. This is done to help remove any bias towards data collection and analysis. Use of a control group is necessary to better identify differences caused by the group receiving the intervention.

A unique recommendation for subject selection is to identify a group that has a high rate of injury or identified lack of sleep.⁶⁰ If the purpose of the study is to monitor TRT's effects on reducing injury, then picking a group that is already more prone to injury will provide more opportunities of observable effects.

The largest disagreement between interview subjects concerns the length of any study. Riebel suggests that the USMC could utilize TRT during a short-duration training event, "Use an outcome of a large physical event like the basic reconnaissance course indoc test."⁶¹ Another option is to introduce TRT during a longer training event such as 30-day training evolution or a month-long field exercise.⁶² The benefit of advocating for a shorter duration study is a lower probability of altering a Marine's natural testosterone production, and it would likely be easier to pass the USMCs institutional review board. Others suggest that TRT research length should be three (3) months up to one year.⁶³ During this longer timeframe a researcher could observe an entire training cycle and more readily identify benefits and any potential side effects. For any further research of TRT in the USMC, emphasis should go towards selecting the correct population and duration with a focus on measuring mission accomplishment outcomes.

Courses of Action (COA) for TRT use in USMC:

COA Discussion

Before conducting any future study into TRT use in the USMC, it is important to first identify where and when TRT would be utilized. Understanding this end state will best guide and inform future research efforts. Based on literature, interviews, and the author's knowledge of the infantry community, there are multiple courses of action (COA) for utilizing TRT within the USMC. Factors such as age, duration of treatment, mission requirements, and MOSs must all be considered.

A COA to examine is the use of TRT across the entire USMC regardless of MOS, age, or mission requirements. The aim of this COA would be to utilize TRT to enable all males to obtain and maintain the high end of normal testosterone level of 500ng/dl.⁶⁴ A potential positive outcome of this wide-spread use could be the reduction in MSKIs brought about by an increase in BMD.⁶⁵ As MSKIs affect all MOSs, not just the ground combat element, the USMC could benefit financially from an overall total-force reduction of MSKIs. The improvements with reduction of depression, and quality sleep associated with TRT⁶⁶ could also benefit the total force. An aircraft mechanic for example might not benefit from an increase in lean-muscle mass as much as an infantry rifleman, but that mechanic would likely benefit from the quality sleep. Implementing this entire USMC COA would require significant support from Navy medicine. For example, if half of the Marines in an infantry battalion were being prescribed TRT, then Navy medicine would have to support quarterly blood-panel analysis for almost 500 Marines. It is likely that Navy medicine would have to reallocate personnel resources to meet this requirement, hire additional sports medicine physicians, or outsource the blood-panel analysis to the civilian sector. Due to testosterone's ability to affect multiple parts of physiology, there is

potential for all USMC populations regardless of age or MOS to benefit from TRT. However, due to the medical support necessary to safely administer TRT to a large population, significant financial resources would have to be reallocated to support large scale TRT prescription.

A more restrictive COA would be to limit the use of TRT to certain MOS populations and ages. Literature explains that males do not typically see any decrement in testosterone until they are at least 30 years old.⁶⁷ As with any medical intervention, there are always going to be associated risks to utilizing TRT. Each person will have slight or potentially large variations to a TRT intervention.⁶⁸ Due to the lack of available research of utilizing TRT on younger populations (less than 29 years of age), the potential long-term side effects are unknown. It is also unknown if the long-term effects would be positive or adverse. If the utilization of TRT in younger USMC populations causes long-term adverse side effects, then it could out-weigh short term gains such as increased lean muscle mass or BMD improvements. Also, it can be argued that physically demanding MOSs will more often be in a high stress environment that causes a drop in testosterone.⁶⁹ Focusing on just physically demanding MOSs would require less Navy medical support than prescribing TRT to all MOSs, and the focus would make the task of analyzing the effects less cumbersome. Utilizing TRT only within a population of males at least 30 years of age and in a physically demanding MOS would target the Marines who could benefit most from the treatment, and the smaller population would be easier to monitor from a Navy medicine and leadership perspective.

The most targeted COA is to utilize TRT only in short durations during operations that are high in unavoidable stressors. An infantry company tasked with defending forward in an expeditionary environment for 30 days will likely be in an environment of little sleep, poor nutrition, and high physio-load. Because of this environment, their testosterone levels will drop

and could lead to a decrement in mission capability.⁷⁰ Prescribing TRT to this group prior to departure of their mission could combat the loss of testosterone and enable the group to maintain the same physical and mental capabilities throughout. Think of a boxer who is as fresh during the last three rounds of a fight as he was during round one. Utilization of a single treatment prior to mission execution would also limit the risk of long-term use side effects. Setting parameters for when this group would require TRT could be troublesome, however. Much consideration would have to focus on determining what constitutes an operating environment that is prolonged high stress. This challenge could prove to be difficult from a medical perspective and even more difficult from a policy perspective. Focusing TRT use based on specific mission requirements could limit risk and still obtain some positive benefits, but it would be challenging to determine which specific mission requirements would meet the criteria for TRT intervention.

Recommended COA

Having high levels of testosterone would benefit all Marines regardless of MOS, mission requirements, or age, but the author recommends a use case scenario of TRT focused on Marines over age 30. This would be a smaller burden on Navy medicine due to the smaller sized population and would make analysis of the program easier to manage. The author also recommends the use of a consistent treatment schedule, regardless of mission profiles, to alleviate the need to identify specific missions that would most benefit from TRT intervention. There is enough literature documenting TRT use on older populations to give confidence that Marines over the age of 30 would benefit from TRT.⁷¹

Note that while the recommendation here is to concentrate on Marines over age 30, use of TRT should also include any Marine under the age of 30 who is at castrate levels of testosterone (less than 250ng/dl). Utilizing TRT on young populations, who are already above the normal

testosterone threshold, may have long-term consequences on a still-developing body. If research can demonstrate there are not going to be long-term adverse effects, then it may be worth considering for younger populations, but research has a long way to go towards this objective.

The USMC should first focus use on GCE Marines aged 30 and above, as there is likely a higher benefit due to the physically demanding nature of these MOSs. The author recommends more TRT research involving this population prior to implementing any COA. Future research of TRT in the USMC should be built towards the goal of identifying the physical and mission performance benefits associated with TRT treatment of this population.

Future Research and Roadblocks:

Future Research

Detailed study of TRT within a military population is necessary before the USMC could start to implement TRT as a HP enhancement capability. Because there is limited research, research should start with small populations and limited measurable outcomes. Follow-on research could then increase in size and complexity. In addition, all research of TRT should also be limited to a male population, as there are currently too many unknowns with TRT in female populations. With the previous caveats in mind, a logical progression of research goals or projects should be: 1) identify Marine biomarkers daily, 2) introduce TRT interventions to a small population (50 subjects) for a 30-90-day period, 3) introduce TRT to a larger population (500 subjects) over a longer period (3-12 months). Following this logical progression of research projects will best enable the USMC to introduce TRT safely and smartly as an enabler of HP optimization. A discussion of this conclusion is provided in the following paragraphs.

Measuring the testosterone levels of Marines daily for a short period of time is easily

executable and would provide great insight to the factors affecting Marines' testosterone levels. Instead of utilizing a blood panel to measure biomarkers, technology exists to measure biomarkers such as testosterone, cortisol, and estrogen through a saliva sample.⁷² A saliva sample does not provide information on as many biomarkers as a blood sample, but it is nonetheless just as accurate at measuring testosterone.⁷³ This research approach could take daily saliva samples from an infantry company over a period of 30 days and observe what testosterone levels look like in different age groups, when Marines are in garrison, and when Marines are in the field. A study of this nature could identify when Marines' testosterone levels are lowest, and when they are likely to benefit from TRT interventions.⁷⁴ Researchers can also take the biomarker data gained from this study and compare it to a Marine's physical capabilities and job performance. This would be a great starting point for TRT research as there is zero risk to the Marines and the data analysis from such a short-term study could be used to provide direction for any follow-on studies.

The study described above could provide a better understanding of the testosterone trends of GCE Marines. These trends could then identify when Marines have the largest testosterone deficiencies and therefore potentially benefit from TRT. Using this information, research into the effects of TRT treatments should then be conducted on a small population over a limited time duration. For example, the USMC could conduct a research project by introducing small amounts of testosterone to GCE populations undergoing extreme stresses.⁷⁵ A good environment for this study would be in a short, physically demanding military school with older (age 27-35) Marines. Infantry Unit Leaders Course would fit this model well as it is one of the most physically demanding schools in the USMC, is predominantly attended by Staff Non-Commissioned Officers, and has 55 training days.⁷⁶ Although it would be preferable to conduct a

study of TRT in a double-blind fashion, it may not be appropriate in a school setting where students are actively competing against each other for class rank.⁷⁷ This study would provide the USMC with a focused look of Marines receiving TRT in a high-stress operational environment.

Once the USMC understands how TRT affects Marines on a short-term basis, research could then examine a group of Marines over an annual training cycle. For this research, the USMC would offer TRT interventions for all Marines over age 30 in an infantry battalion. Per literature recommendations, it would be imperative that these Marines be monitored by a physician at least every 90 days.⁷⁸ With the correct monitoring procedures and precise doses based on individuals identified, this research can then follow the Marines of the battalion throughout a pre-deployment training evolution and possibly even a deployment. Measuring the mission success of this battalion compared to other like-sized units at USMC battalion certification exercises would determine if TRT equates to a higher degree of mission accomplishment across the unit. This type of longer-term research may carry more risk than a shorter duration research project, but a study of this nature is required to either prove or disprove TRT's ability to equate to not just HP optimization but to success on the battlefield.

Roadblocks

TRT needs to overcome some challenges for the USMC to accept it as a viable HP optimization method. Policy in Navy medicine regarding TRT, misunderstanding of TRT by non-medical personnel, and America's attitudes towards TRT use in the military are all considerations that cannot be ignored.

Navy medicine does not view TRT as an HP optimization option. As with other medical professionals, Navy medicine's goal is to treat injury and illness, not necessarily to prevent

injury or optimize human performance. TRT is currently prescribed only to individuals in the military showing castrate levels of testosterone that can severely impact overall health.⁷⁹

Interview subjects perceive that there is a negative attitude towards the use of TRT in Navy medicine.⁸⁰ Whether there is a real or perceived aversion by Navy medical providers towards the use of TRT, there is no policy that states TRT can be utilized for HP purposes.⁸¹ Without a guiding policy explaining to Navy medical providers that TRT is an effective intervention for HP optimization, attitudes towards its use will likely not change. TRT research in military populations must inform this policy. If TRT use is not codified in written policy, then Navy medicine buy-in to the use of TRT will likely remain low.

USMC leadership will have to make a concerted effort to inform Marines of the differences between TRT and AAS abuse. Even as there are misunderstandings about TRT in the medical community, there is likely a much larger misunderstanding within the military population due to lack of training and understanding of human performance. The current generation of military personnel has grown up in a society that demonizes anabolic steroid use of any kind and preaches that taking steroids gives an “unfair” advantage. Explaining to Marines that taking TRT for HP purposes is not the same as AAS abuse⁸² is important to give Marines confidence that TRT is in no way dishonorable, is safe under certain conditions, and the side effects are minimal with monitored TRT usage.⁸³ The messaging would have to come not just from USMC leadership, but from Navy medicine leadership as well. Just as with any other medical intervention, the USMC has a responsibility to ensure its Marines are fully informed of the risks, benefits, and why they are taking the intervention.

The USMC must consider how their use of TRT could affect the civilian population. The civilian population is directly tied to the USMC as civilians are the USMC’s recruitment pool,

Marines live amongst the civilian population, and Marines eventually transition back to society.⁸⁴

The same misunderstanding of the difference between TRT and AAS abuse that exist in the military are likely going to exist within the civilian population. What happens to the teenager who is thinking of joining the Marines but gets misinformed that all Marines are taking anabolic steroids?⁸⁵ This individual may think they are not strong enough to be in the Marines unless they also start taking steroids. There is potential for TRT use by the USMC to send the wrong and potentially dangerous message to the civilian sector. Use of TRT in the USMC therefore should not be conducted in secret, but in well documented open-source media. Controlling the public narrative by use of USMC public affairs would illuminate that TRT use by the USMC is honorable, safe, and not the same thing as anabolic steroid abuse. A thorough information campaign surrounding TRT, even during research, must be executed by the USMC or public support would quickly be lost.

There are topics not discussed in this paper that warrant further deliberation and are beyond the scope of this paper. For example, civilian doctors utilize TRT to treat depression, which may be a promising treatment for Marines to aid in combatting suicide, but a follow-on research effort would have to validate this idea. TRT research points to potential increases in cognitive performance, and if this concept of TRT use is validated, then it will likely prove to be of great value to the USMC. Also, the civilian sector's use of TRT and other hormone replacement therapy often focuses on a male population. More research and discussion must occur regarding the use of hormone replacement therapy for female Marines. Lastly, the cost associated with TRT interventions on a large scale to the USMC is unknown and could be a point of concern. Even though these topics deserve exploration, enough research exists currently for the USMC to confidently take small steps towards TRT utilization.

Conclusion:

The USMC has made some strides towards HP optimization in recent years. The recent creation of the MCPFP and Force Fitness Instructor Program is an investment of personnel towards HP optimization not seen previously. The USMC has also invested financially with the hiring of civilian-certified athletic trainers as part of the SMIP program to provide Marines a professional athlete level of care. Even with these strides, however, the USMC is not taking advantage of other HP optimization capabilities such as TRT.

TRT is shown to create physiological improvements that would be beneficial to Marines, particularly in the GCE. Increase of lean muscle mass, increase of BMD, and a reduction of injuries are all observed effects with this treatment. Subject matter experts agree that TRT could be beneficial to GCE Marines for these reasons. All documented effects of TRT would certainly improve HP optimization and may lead to greater mission accomplishment. Although there is a lack of research in the application of TRT in military populations, this should not dissuade the USMC from exploring TRT's potentially groundbreaking advancement of HP optimization. The USMC should invest in TRT utilization and research to provide its Marines with every possible advantage heading into the next peer-to-peer conflict.

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