Program Design Based on Genetically-Determined

Type I and Type II Fiber Typing

In Order to Achieve Optimal Athletic Performance

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by

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DEDICATION

I dedicate this thesis to my wife loving wife, Oralia. It is because of her never-ending love, support and encouragement that I was able to fully commit to my lifelong passion and vision through a higher educational standard that was required by the curriculum within this field of study. I also want to dedicate this to my loving parents, who are the educators who have given me the tools to follow my dreams through their inspiration for me to achieve higher. Ultimately, I want to dedicate this thesis to my Heavenly Father, Jesus Christ. It is because of Him, that I have been blessed with my wife, parents and many loved ones that have positively impacted my life for me to have the intestinal fortitude to accomplish this educational goal.

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ABSTRACT OF THE CAPSTONE PROJECT Program Design Based on Genetically-Determined Fiber Typing In Order to Achieve Optimal Athletic Performance by Daniel J. Borowick, American Public University System, January 26, 2020 Charles Town, West Virginia, Professor Daniel Graetzer, Capstone Project Professor.

In order to achieve optimal athletic performance in sports and/or in pursuit of physical fitness, designing a program based upon genetically-determined fiber typing is paramount. An individual cannot alter their genetic code and therefore, depending on what genetics a person is gifted with, will determine to a large extent how well they can perform in certain athletic performances, sports or physical fitness. The human body is made of skeletal muscle and that skeletal muscle is comprised of muscle fibers. There are two types of muscle fibers in the body and they are grouped into two separate characteristics of being either slow twitch or fast twitch muscle fibers. The slow twitch (ST) muscle fibers are classified as Type I fibers. The fast twitch (FT) muscle fibers are called Type II. Type I only contains one type of fiber, whereas Type II has two subtypes and they can be further divided into Type II A and Type II B. (Powers & Howley 2015, pg. 173). It is these muscle fiber types that are called upon for activation for not only normal functioning of the human body on a daily basis but also for the athletic performance of the individual. Therefore, depending on what type of muscle fiber is found mainly in the individual based upon their genetics, will to a large degree determine what they will be predisposed to perform better in athletically as the amount of force used in an event, is determined upon by the muscle fiber that is recruited.

It is through the precise implementation of a proper program design of resistance training, endurance training, concurrent training, plyometrics, balance and flexibility training that the

athlete can improve their athletic performance for optimal function. This program design will be based on the implementation of short and long-term goals. These goals will be based upon the S-M-A-R-T Goal System which are defined further as the goals being specific, measurable, attainable, relevant and time based (Seguin, Epping, Buchner, Bloch & Nelson, 2002). In this instance, the long-term goal would be to improve balance and the short-term goal would be starting the strength training program. These goals are measurable and quantified as same if the program has actually begun. Prior to starting a strength and training regimen, a physician needs to see the individual and if determined the individual can begin, then the goal will be attainable. Relevancy refers to how the goals will assist the individual achieve a long healthy life and help the athlete achieve optimal athletic performance. Lastly, the goals are time based if the program commences immediately. When these goals are established in attaining the vision, a successful outcome is more within reach as a clearly defined framework is delineated in achieving the measurable and quantified goals (Ogbeiwi 2017). This can be based upon the proper prescription and manipulation of the exact volume, load, frequency and intensity that is necessary to recruit the targeted muscle fiber types to improve for the desired athletic performance of the individual. Furthermore, the larger the amount of muscle fibers present, allow for better force and torque production of that specific muscle.

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CHAPTER 1 INTRODUCTION

Type I fibers contract slowly, focusing on small incremental and sustained movements and are highly resistant to becoming fatigued. Their genetic makeup includes small motor neurons, fiber diameter, dense in capillary presence, high levels of mitochondria and myoglobin. They exhibit small doses of creatine phosphate (therefore, unable to deliver quick, forceful movements like Type II), low in glycogen, (which cannot deliver production of ATP rapidly which helps sustain high levels of energy), and an abundance of stored fat, also known as triglycerides. Because of these inherent characteristics of Type I fibers, they are structurally conducive for any activity that does not require high recruitment of force from the muscle (Karp 2001). Type I fibers are called red fibers because of the high degree of blood presence. These activities include daily duties such as walking and regular movement patterns. In physical exercise, these activities include endurance based events like jogging, marathon running events and swimming. A program design can be implemented for the individual to work on an exact repetition scheme to improve athletic performance that recruits these specific Type I fibers and would include training to improve levels of muscular endurance.

Table 1: Characteristics of the Three Muscle Fiber Types (Karp, 2001).

Table 1: Characteristics of the Three Muscle Fiber Types.

Fiber Type	Slow-Twitch (ST)	Fast-Twitch A (FT-A)	Fast-Twitch B (FT-B)
Contraction time	Slow	Fast	Very Fast
Size of motor neuron	Small	Large	Very Large
Resistance to fatigue	High	Intermediate	Low
Activity used for	Aerobic	Long-term Anaerobic	Short-term Anaerobic
Force production	Low	High	Very High
Mitochondrial density	High	High	Low
Capillary density	High	Intermediate	Low
Oxidative capacity	High	High	Low
Glycolytic capacity	Low	High	High
Major storage fuel	Triglycerides	CP, Glycogen	CP, Glycogen

Type II fibers are the exact opposite genetically of Type I fibers. Type II A, which is a cross-section or the intermediary between Type I and Type II B, have a moderate resistance to fatigue, contain a motor neuron large in size, have medium capillary density and an average content of myoglobin. They are quite high in mitochondrial content and in creatine phosphate, (which delivers the quick explosive movements required of this fiber), higher quantity of glycogen and an average of stored fat or triglyceride stores. They have a larger presence of glycogen and oxidative activity which enables higher force production (Karp 2001). Activities that are anaerobic in nature with a high output of force such as track activities of the 300 and 400-yard dashes, certain sports and weightlifting recruit these fiber types. A program design can be implemented for the individual to work on an exact repetition scheme to improve athletic performance that recruits these specific Type II A fibers and would include training to improve levels of muscular strength, power, speed and hypertrophy.

Type II B fibers are extremely sensitive in fatiguing, contain large motor neurons and fiber diameter. They are low in mitochondrial content, as well as in myoglobin content and capillary density. They are the highest force multiplier of the all the muscle fibers and therefore contain high amounts of creatine phosphate and glycogen. They are low in stored fat or triglycerides and oxidative enzymes but high in glycolytic enzymes (Karp 2001). These muscle fiber types are recruited for all quick bursts of energy in an anaerobic capacity. These fibers are recruited in track and field events like the 100-meter sprint or hurdles, various physical sports to include football, basketball and weightlifting. A program design can be implemented for the individual to work on an exact repetition scheme to improve athletic performance that recruits specific Type II B fibers and would include training to improve levels of muscular strength, power, speed, endurance, agility, flexibility and balance.

These muscle fibers all collectively contain three biochemical properties that aid in the movement of the skeletal muscle. These properties include, oxidative capacity, type of myosin isoform and the large amounts of contractile protein inside the fiber itself. A muscle with a high oxidative capacity, such as Type I, will be beneficial during bouts of high aerobic exercise and consequently resistant to fatigue when the exercise is performed on a submaximal basis. This capacity is based upon the amount of mitochondria, degree of myoglobin in the fiber and the amount of capillaries encompassing the fiber. The mitochondria are the driving forces of the human body present within our bodies cells, and produce ATP which helps the body perform aerobically better. They produce energy as they take the macronutrients of fat and protein with sugar, and then with the presence of oxygen, covert them to energy. When a muscle fiber, such as Type II, is surrounded by great amounts of capillaries, they are better equipped to perform muscular contractions that are needed in events requiring power, strength, speed and torque. Myoglobin in the blood transports the O2 between the mitochondria and the cell membrane. Therefore, when a muscle fiber, such as Type I, contains large amounts of myoglobin, mitochondria and capillaries, they will exhibit high aerobic potential, be resistant to fatigue and proficient in submaximal exercise. Consequently, when a muscle fiber, such as Type II A and Type II B, contain lower amounts of myoglobin, mitochondria and capillaries, they will exhibit low aerobic potential, or high anaerobic potential, susceptible to fatigue and proficient in maximal exercise. The type of myosin isoform is important because they differ in ATPase function or the way they disrupt or break down ATP. If a muscle has a high degree of ATPase it can then breakdown quickly to produce the muscle shortening quickly which is necessary for Type II fibers. In muscles that contain large amount of the protein, actin and myosin, it is these muscles that can produce greater amounts of force, as the myosin cross bridges join together with actin. It is this actomyosin bond that encompasses raising and lowering thermal levels in the muscle fiber and subsequently produces the actual force (Karatzaferi, C. et. al. 2004).

On the contrary, muscle fibers with a low degree of ATPase breakdown slowly and the muscle contracts at slower speeds present in Type I fibers. Lastly, if a muscle fiber contains great amount of the proteins like actin and myosin, they are better equipped to produce force in greater amounts like in Type II fibers as opposed to low amounts of actin and myosin which give a small force production as in Type I fibers (Powers & Howley 2015, pg. 174).

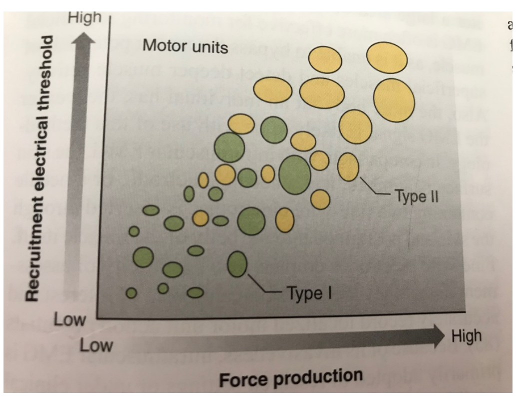

Figure 1: Force Production in Muscle Fiber Types (Powers & Howley, pg. 91).

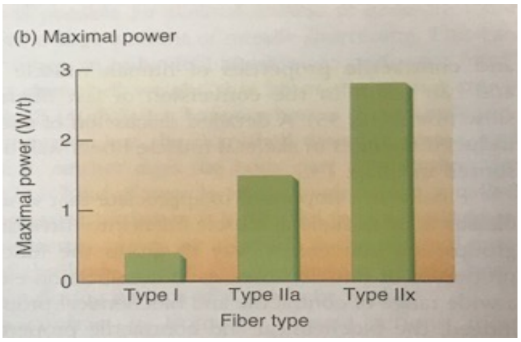

Figure 2: Force Production in Muscle Fiber Types (Powers & Howley, pg. 175).

Therefore, it is because of the individual chemical makeup of differing skeletal muscle fiber types in the human body, that some individuals contain a larger degree of Type I muscle fibers as opposed to those who exhibit more of Type II muscle fibers. It is up to the individual and more importantly the strength and conditioning coach or athletic trainer to recognize which type the athlete or individual exhibits in more abundance. Once this is determined, a program design can be implemented in order to improve the intended sport or endeavor to improve athletic performance based upon focusing on that specific genetic makeup. It is through this carefully crafted program design that emphasizes a chronological periodization plan so to avoid overtraining, which will produce the best results for the athlete, and/or individual (Graetzer 1993).

Chapter 2 Literature Review

Implementation of the appropriate program design.

Before a prescription can be written for an exercise regimen for an individual or athlete, it is necessary to see what the definition of physical fitness is precisely. Physical fitness is "the ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure pursuits and to meet unforeseen emergencies." Physical fitness is operationalized as ‘‘a set of measurable health and skill-related attributes’’ that include cardiorespiratory fitness, muscular strength and endurance, body composition and flexibility, balance, agility and reaction time. This definition defined by the American Council of Sports Medicine (ACSM), is considered one of the premiere organizations that promote research into the integration of sports medicine and exercise science. The ACSM advocates a detailed program design based upon those aforementioned attributes to affect a reduction in musculoskeletal and Cardiovascular Health Disease (CHD) such as obesity, being overweight, Type II diabetes, coronary artery disease, high blood pressure and cardiac heart attack. Therefore, it is though the oversight of a qualified fitness professional that can improve the accountability to exercise which in turn brings about a reduction in the CHD instances. It is this qualified professional that can assist both beginning exercisers, individuals with health complications, athletes and advanced athletes with a proper program design (Garber et. al., 2011). However, it is equally the responsibility of this professional to extract the desired goals of the individual to bring about optimal athletic performance in their objective. It is these guidelines that are general in nature but are more detailed and focused for a specific population. An athlete that is preparing for an athletic competition will be trained depending whether they are in their pre-season, in-season or off-season training. Furthermore, more specifically, in the military, law enforcement and firefighter community, the program design will additionally be different as it will be geared to a program design that takes into account the varying degree of external loads placed upon the body and skeletal system through the use of their respective uniforms and their daily physical duties.

Analysis of the Sport and the Athlete Prior to Program Design

Previously, a study had been conducted in which it was discovered that utilizing an athlete's genetics in conjunction with a precise training method geared toward that genotype, produces more advantageous resistance training session for the athlete. The study sought out to see the athlete's potential for enhancing their attributes of power and endurance through either high or low intensity resistance based training programs. In this study, they took two groups which consisted of soccer players in one group and athletes from various sports in another group. In this study, exercises chosen that were non-weight bearing is an advantage to those athletes that due not engage in a program design that includes a lot of weighted resistance trained exercises. Therefore, this study therefore benefits those individuals, the soccer players, that use primarily the glycolytic and oxidative energy system during their respective sport and did not engage in weight bearing exercises. They were further assigned 8 weeks of resistance training that either did match or did not match their genetics. The variables used to measure explosive power and aerobic fitness were a counter measure jump (CMJ) and aerobic 3-min cycle test (Aero3), both pre-and post-test 8 weeks of the study. It was discovered that the athletes or the matched groups using high intensity resistance training that is in direct correlation with their genotype and the matched groups using low intensity training with their exact genotype, increased significant measures of their CMJ and Aero3. On the contrary, the mismatched group, who trained opposite their genotype, exhibited non-significant improvements and less improvement in the Aero3 (Jones et. al., 2016). Therefore, this is a recent study that shows a direct correlation between creating and implementing a precise program design for an individual that meets their exact genotype. As seen in this study, the athlete will achieve optimal athletic performance as a result of training that is designed upon their genetic potential. It is the genetic potential that is comprised of the Type I or Type II A or Type II B fiber types that will achieve these same results. When it comes to the tactical athlete of the military, law enforcement or firefighter community, there is no set percentage that is scientifically proven to have the tactical athlete return to duty after an injury which has placed the athlete in a "detraining period." All athletes deal with injuries in their own individualized way and in addition to the physical aspect, these tactical operators must be physiologically ready to engage in their profession. Furthermore, there is the concern of re-injuring the previously affected bone, joint or connective tissue and a safe return is once again individualized. Due to these factors, it will be the decision of all parties involved from a supervisory capacity to determine whether the tactical athlete is ready to return to duty based on a series of both physical and psychological tests.

Comparisons of CMJ and Aero3 increases (%) in response to resistance training between matched and mismatched groups.

Study	Group				P_3
	Matched athletes		Mismatched athletes		
Study 1	n =14	P_1 (paired test)	n = 14	P_2 (paired test)	
Change in CMJ,%	7.8 (5.9)	0.0005*	2.9 (7.2)	0.175	0.0596
Change in Aero3,%	4.0 (3.1)	0.0004*	2.8 (4.3)	0.0134*	0.2456
Study 2	n =20		n = 19		
Change in CMJ,%	7.1 (4.1)	<0.0001*	2.4 (3.5)	0.0053*	<0.0001*
Change in Aero3,%	7.7 (2.2)	<0.0001*	1.9 (1.8)	0.0004*	<0.0001*
Studies 1 and 2	n =34		n =33		
Change in CMJ,%	7.4 (4.9)	<0.0001*	2.6 (5.3)	0.0152*	<0.0001*
Change in Aero3,%	6.2 (3.2)	<0.0001*	2.3 (3.1)	<0.0001*	<0.0001*

*Note: P_1 and $P_2 < 0.05$ - significant increases in CMJ and Aero3 (paired test); *P3 < 0.05 - significant difference between matched and mismatched groups. Matched athletes - high-intensity trained with endurance genotype or low-intensity trained with power genotype; mismatched athletes - high-intensity trained with power genotype or low-intensity trained with endurance genotype.

Figure 3: Comparisons of CMJ and Aero 3 (Jones 2016).

It is this proper program design that is prescribed with a proper nutritional program that resistance training will result in heightened levels of power, strength, speed, muscular endurance, muscle size, coordination, flexibility and a lowering of blood pressure and body fat. (Kraemer et. al 2004). Scientifically speaking, the athlete that is slow-twitch muscle fiber dominant will respond better in training that is prescribed for low-intensity resistance/aerobic (endurance) training. On the other end of the spectrum, it is the athlete that is fast-twitch dominant that will respond better in training that is prescribed for high-intensity, which is prescribed to develop strength, torque, force and power. This is evident in endurance level athletes at the top levels who are slow twitch dominant and are in abundance is sports such as marathons, triathlons and bicycle road races. Consequently, world class athletes who are fast twitch dominant thrive is competitive sports such as sprinters and weightlifters (Anderson et. al., 2000). With this in mind, what are the types of program design for the athlete that will produce the optimal athletic performance that they desire? What is the type of repetition schemes that they must employ during their workouts? How do you prescribe properly the volume, load, frequency and intensity that is necessary to recruit the targeted muscle fiber types in training for the desired athletic performance? The work performed of repetitions, sets, frequency and intensity refers to volume. The actual amount of resistance used during the exercise identifies load. The amount of days during the week performed refers to frequency. Lastly, intensity refers to the level of difficulty of the work in the program design. It is the precise weight or resistance utilized during the exercise and the higher the intensity, the lower the reps. The repetitions will in turn be higher as the intensity is lowered (Borowick 2019).

On the initial basis, the strength and conditioning professional needs to analyze the athlete which takes into account what the sport the athlete is engaged in and what it requires of the athlete and also assessment of the individual athlete themselves. For the purposes of this capstone assignment, this author will analyze two separate athletes that are involved in two separate sports and are well conditioned athletes. Athlete A will be the individual that is fast twitch dominant and is involved in his preseason program design playing for a high school football team as a linebacker. The second athlete, Athlete B, will be slow twitch dominant and is involved as a professional marathon runner and at the beginning of the in-season. When it comes to the evaluation of the sport, focus needs to be paid attention upon analysis of movement (body and limb movement), analysis of physiology (power, strength, hypertrophy and muscular endurance) and lastly analysis of injury (which areas of the body are more susceptible to injury through the sport performance). Upon evaluation of the athlete, the professional needs to focus on what are the goals of the athlete, determine their 1 Rep Max, or maximal strength testing, in certain key exercises, assess the scores and then design a program based upon what their goals are. Examples of proper test selection for these athletes would include the bench press or shoulder press for Athlete A and the squat and power clean for athlete B. Although science has progressed instrumentally through the years and the significance of weight training for all athletes in all types of sports, those engaged in endurance sports, specifically cross-country skiing and marathon running tend to shy away from resistance training. Studies have been conducted and it has been shown that the endurance athletes running economy has been improved due to resistance training (Saunders, et. al., 2004). It is through a thorough and precise assessment of the athlete that a specific resistance training program can be implemented. Other factors that come into play for the athlete is their training history, what type of technique do they exhibit in their resistance training and what was their previous intensity.

After those assessments have been conducted it is time to focus on the primary objective or goal of the athlete. Depending on whether they are in pre-season or in season will dictate the training volume established. When athlete is in pre-season they are placed on medium intensity and work on strength, power or muscular endurance. When an athlete is in season, they are placed on a maintenance stage that was developed in the preseason. When in the active rest stage or post season, the training can decompress but will vary and may not include resistance type exercises or the actual practiced sport. Lastly, in the off-season, the training will be of high-intensity and progress from muscular endurance to strength and power at the end of the program. The next step in the program design will be the selection of the best suited exercise. The exercises will be either core exercises which activates muscle parts that encompass more than one large area which include the chest, shoulder, back and thigh. These exercises can then be divided into multi-joint and single joint exercises. Multi-joint or compound exercises are the primary choice in program design because it is specifically related to the chosen sport. Single joint or isolation exercises are viewed as accessory muscles and assistance exercises as they do not directly contribute to the proficiency in the sport. These include smaller areas of muscle such as the biceps, the abdominals, calf, forearms and neck (Baechle & Earle, 2008). Although they are secondary in program design, they are not to be overlooked as they can afford the individual to train that muscle as an isolation exercise. It should be noted that the triceps brachii is not actually a small muscle but quite large. However, the triceps brachii and the triceps pushdown exercise (a single joint movement), is usually misconstrued as “working a smaller muscle,” when in fact it is not). It should more appropriately termed that the amount of muscle mass in movement during this exercise is less than that of a multi-joint exercise such as the bench press (Ribeiro et. al., 2017). During the program design of whether the athlete uses a single joint or multi-joint exercise, the subject of overreaching is something both the athlete and the coach need to be cognizant of. Overreaching is a state of excessive volume or intensity during the program design that produces in a negative performance of the specific athletic performance. Overreaching can be described when the athlete reaches the "tipping point." It is the sequential prescription of recovery and proper rest that the athlete's performance can then be increased or become positive after only encountering a bout of temporary negative performance. sideline the athlete for up to two to three months and is characterized by terms of burnout, failure adaptation, muscle failure syndrome and excessive exercise (Kreher J. B. (2016). Overtraining can lead to a medical diagnosis of incurring rhabdomyolysis which is a breakdown of muscle tissue resulting in the protein myoglobin being released into the bodies bloodstream which can have a negative effect and detriment to the kidneys. Regardless what the sport is, whether football for Athlete A or marathon running for Athlete B, the training for the individual has to be specific and transfer directly to their sport. This design of specificity is referred to as the Specific Adaptation to Imposed Demands or the SAID Principle (Baechle & Earle, 2008). Additionally, it has been studied and shown that an exact program design and its prescribed doses can fight off diseases such as cognitive decline (Herold, et. al., 2019).

General exercise variables relevant in a single session	
Exercise intensity	The exercise intensity describes how strenuous the exercise is.
Exercise duration	Time period that is spent for a specific exercise or the entire exercise session.
Type of exercise	Type(s) of exercise(s) that is (are) used in the exercise session (e.g., cycling, dancing).
General training variables relevant in a training program	
Frequency	The number of training sessions across a distinct time interval.
Density	Distribution of training sessions across a distinct time interval with regard to recovery time in-between training sessions.
Duration	Duration over which a training program is carried out.
General training principles relevant in a training program	
Variation	To prolong adaptations over a distinct training duration, systematic manipulation (variation) of exercise variables and training variables is necessary.
Specificity	To elicit a desired adaptation, the stimuli provided by the used physical exercises must be tailored to the desired adaptations (s).
Overload	To improve a distinct type of fitness, an appropriate stimulus must be provided that exceeds the already-existing individual capacities to a distinct extent.
Progression	To ensure continuous improvements, the stimulus must be appropriately modified over time (e.g., increase in external load).
Reversibility	Once the physical intervention induced stimulus is removed (e.g., stop the training), de-adaptational process will occur, and the changes in fitness level will eventually return to the baseline level.
Periodization and programming	In this context, periodization and programming are crucial elements for an appropriate exercise prescription. Periodization is the temporal coordination of training periods with specific fitness characteristics (e.g., strength or endurance) and application of training principles, which is referred to as macromanagement. Programming describes the organization of exercise variables and training variables (micromanagement). Periodization includes various forms such as linear periodization (LP) or non-linear periodization (NLP). In LP, typically, a gradual increase in intensity is conducted, whereas in NLP, exercise prescription is changed on weekly or daily basis.

The definitions are based on Stone et al. (2002), Ratamess et al. (2009), Campbell et al. (2012), Winters-Stone et al. (2014) and Törpel et al. (2018).

Figure 4: Relevant Exercise Variables (Herold et. al., 2019).

Chapter 3 Project Proposal

Multi-Joint/Compound Exercises and Single Joint/Isolation Movements

Whether training the Type A athlete who is fast twitch dominant or the Type B athlete who is slow twitch dominant, they both can use the same types of multi-joint/compound or single-joint/isolation exercises. The types of exercises that are multi-joint and train large amounts of muscle mass, involve two or more joints and focus on the core include the back squat, front squat, hexagonal bar squat, barbell bench press, clean, high clean, push press, shoulder press, barbell deadlift, Romanian deadlift, barbell row, chest/tricep dip and pull-ups/chin-ups. The single joint/isolation exercises that train smaller accessory muscles, utilize only one joint include the barbell curl, pectoral flyes, triceps extensions, leg extensions, hamstring curls, forearm curls, cable chest presses, barbell shrugs, dumbbell raises, dumbbell rows, concentration curls, hammer curls and calf raises. As mentioned previously, compound exercises are more specific to the actual sport itself but the isolation exercises can be used as a method to target a precise location to correct a deficiency or imbalance in the muscle, or for recovery during a detraining phase.

After completing the analysis for the athlete, their sport, their history and after the goals have been analyzed and assessed, it is time to implement the actual program design based upon their exact genotype. This program will be based upon periodization cycles of macrocycles, micro-cycles and meso-cycles. The macrocycle is the overall program design length, the micro-cycle is a 2 to 3 week period within the macrocycle and the meso-cycle is the preparation stage of hypertrophy, strength and power. Multiple variables during the program will be manipulated during this program which will be frequency, volume, intensity (Borowick 2019).

In this authors example, Athlete A will be the individual that is fast twitch dominant and is involved in his preseason program design playing for a high school team as a linebacker. The chosen prescription of program design for Athlete A will be primarily of compound movements rather than isolation movements. The chronological progression of the preseason program for resistance training will go from stability, to muscular endurance, to building mass, to maximum strength and then lastly power training. The stability portion begins as the foundation and consists of high reps and low intensity. The muscular endurance is designed to be a moderate intensity, yet still challenging. This initial stage would be a micro cycle in which the muscular endurance phase would be designed at 3 days of training per week (frequency of how many times per week the exercises are performed), with concentration on a sport specificity, SAID Principle), and then to 3 times per week in the initial meso-cycle. The prescription here would be for 3-6 sets of 10-20 repetitions at a low intensity of no more than 50-75% of the 1 Repetition Maximum (RM). The next phase of building mass will focus on full body-strength routines with high volume of reps as intensity and sets increase and reps decrease to below 8, whereas repetitions between 8 and 12 would be a hypertrophy stage in order to build muscle. Next under maximum strength and subsequent meso-cycles, the weights get a lot heavier with fewer reps. It is here that the hypertrophy phase evolves to a strength phase, where the workouts will involve 3-5 sets of 4-8 repetitions with high intensity of 80-90% of the 1RM. After the strength phase is the final and very critical stage of power. It is here that the power phase utilizes low volume and no more than 5 sets. These 5 sets are at a high intensity which is 90-95% of the athlete's 1RM (Borowick 2019).

The power phase will be conducted through full complex exercises with high intensity strength exercises then followed by low-intensity power exercises with a focus on speed and explosiveness. Examples of this can be a clean and press, high clean or clean and jerk. It is the maximum strength, speed and power phases of the training that Athlete A will be focusing on his Type II A or Type II B muscle fibers and developing their max potential to give them optimal performance which will translate onto the football field. It is this chronological progression that will have Athlete A, using the SAID principle to train on exactly what he/she needs for their desired sport. During this phase, weight is important, but maximal or near maximal effort is more essential at the end of the repetition range. It is this intensity and maximal exertion that recruits fiber recruitment from low threshold to high threshold motor units (Bass 2014) and produces the desired training effect of emphasis for the Type II A and Type II B muscle fiber recruitment.

In the program design for the professional marathon runner who is in season, different program designs need to be designed. First and foremost, because of this macrocycle program, their goal is not to add any more strength or power but to maintain their pre-season program. Also, since marathon running recruits slow twitch or Type I muscle fibers, Athlete B needs to be very careful that with a resistance based program they do not overtrain. Previous thought concepts have echoed sentiment that the more muscle you have and the extra muscle you have will be counterproductive to the goals of endurance running and Type I fibers. On the contrary, when Athlete B utilizes a resistance training program, they will be able to prevent injury by strengthening tendons and connective tissues. Also, it may increase their speed by improving neuromuscular coordination and power by better running economy and a more efficient stride. Balsalobre-Fernández, et. al., 2016). Additionally, resistance training because of improvements to running economy, will also improve flexibility and make up a stronger core. Athlete B can utilize the same exercises as Athlete A described above, however, their repetitions will need to be that of a low intensity, with high repetitions and utilizing 50-75% of their 1 Rep Max to solely concentrate on muscular endurance. It is this strategy of program design early on and throughout their macrocycle that they will need to focus on muscular endurance and therefore keep the repetitions high. It is endurance sports such as marathon running that studies have shown that these elite athletes have a slow twitch fiber percentage as high as 90-95%. On the contrary, sports that require fast twitch fibers such as sprinting and Athlete A, exhibit fast twitch fibers between 60 to 80 % (Aagaard, et. al 1998).

Plyometrics Training

Aside from strength and resistance training, both Athlete A and B can work on their Type I and Type II A and B fiber types through plyometric training. Plyometric training is physical training that is high in intensity through short intervals. Plyometrics turn the gains in strength from resistance training into the explosiveness and speed on the field or in the respective chosen sport. They are typically exercises that uses the athletes own bodyweight that can be added to increase the intensity. The ultimate goal of plyometric training is to achieve a higher level of power which includes speed and strength. It is critical to not conduct plyometric training on a daily basis so in order to emphasize quality and not quantity in plyometric training. If the focusbecomes quantity, then too much stress will be placed upon the body and muscular fatigue will be an unwanted result of this training due to plyometrics impact upon the body. In order to not overtrain, it is recommended to include plyometric training no more than three days per week.

On its elementary basis, you can take a lunge or a squat and add a leaping or jumping portion to the exercise. Plyometric training is an optimal part of sport conditioning and the jump is the plyometric element which elevates cardiovascular output and muscular contractions. The plyometric exercises, because of their focus on short bursts of sub-maximal and maximal effort are conducive to emphasizing utilization of Type II A and B muscle fibers. Plyometrics can be performed initially in the workout as simple box drills with foot placement moving in unison or opposite movements to build power and muscular coordination. After this initial warmup, the volume will increase to more dynamic movements with maximum velocity. Some examples of these exercises can be power skips, depth jumps, squat jumps, countermovement jumps, drop jumps, lunge to knee skip, long jumps, repeated long jumps, power thrusts to name a few. Plyos that are specifically geared to football players would be designed and include the following: single-leg forward hops between ladder spaces including going forward and in reverse; lateral jumping in and out of ladder spaces; Tire drills with a medicine ball; sprinting diagonally; backward and forward crabwalks and push-ups for power in between ladder spaces; medicine ball throws and trunk plyos such as a plank.

A proper rest is required between sets and first and foremost, it will vary depending on whether the individual is conducting the exercises with a high degree of intensity. A good rule of plyometric training to achieve maximal power and speed would be from three to six sets of anywhere between 3 to 8 to powerful repetitions. With that in mind, power and speed are the goals in plyometric training and plyometrics are not to be used as conditioning drills. They need to be done precisely with powerful and quick movements. Anything more than this and it becomes more of a cardio workout and you are not taking advantage of the stretch-shortening cycle at the heart of plyometrics. The stretch-shortening cycle or "SSC" is a three-step process in which the muscles slow down the momentum of the body, then hold on for a second or two at the ground with that energy and then subsequently turn that energy into a movement that is generated with a forceful movement (Stack 2019).

Table 2: Stretch Shortening Cycle: Baechle & Earle 2008, pg. 416.

Stretch-Shortening Cycle

Phase	Action	Physiological event
I—Eccentric	Stretch of the agonist muscle	▪ Elastic energy is stored in the series elastic component. ▪ Muscle spindles are stimulated.
II—Amortization	Pause between phases I and III	▪ Type Ia afferent nerves synapse with alpha motor neurons. ▪ Alpha motor neurons transmit signals to agonist muscle group.
III—Concentric	Shortening of agonist muscle fibers	▪ Elastic energy is released from the series elastic component. ▪ Alpha motor neurons stimulate the agonist muscle group.

According to a meta-analysis comprised of fifteen studies it was revealed that plyometrics has a significant impact on strength gains and those gains have been reported as more than 20 kilograms in tested subjects. More importantly, even better strength gains were discovered when plyometric training was performed with other training such as pairing weight training with plyometrics or “concurrent training.” Concurrent training would be training program that includes both resistance based and endurance based training in the same program design for optimal athletic performance. This is critical as it demonstrates the relevancy for athletes looking to achieve optimal athletic performance. Additionally, this meta-analysis also illustrated that individuals that were either highly trained or trained to a lesser degree can benefit significantly from plyometric training. The analysis found that the volume should be more than 40 jumps per session, with more than 15 sessions per program design in order to achieve the most significant results in performance (Sáez-Sáez et al. 2010).

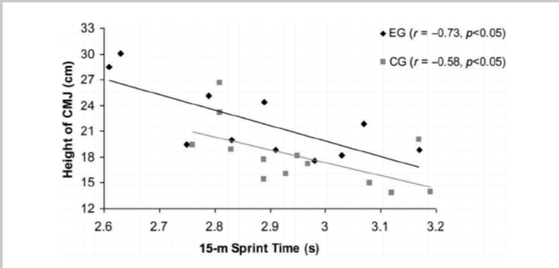

Figure 1. Correlation between countermovement jump (CMJ) (centimeters) and 15-m sprint time (seconds) in the S and C groups at posttest.

Figure 5: Correlation of CMJ between groups. Sáez-Sáez et al. 2010.

Plyometric training has been proven to not only be beneficial in achieving optimal athletic performance in adults but also in pre-pubertal soccer players that were 8 and 9 years old. In a 26 week strength and high intensity plyometric training program, an experimental group conducted strength and plyometrics training before soccer specific training. Results revealed that at posttest time, significant results were found in the plyometric testing such as the countermovement jump (CMJ), and even measures of flexibility. Most noteworthy of all was with the experimental group, in which it was discovered that using strength and plyometrics training resulted in a beneficial effect on their soccer playing capabilities (Ferrete et. al., 2014).

In a study that is germain to the Athlete A football player with Type II dominant genetic composition, it included 30 football players between the ages of 15-25. Based upon the plyometric training it revealed that their overall agility was improved to a significant degree. Thusly, plyometric training methods were prescribed in order to improve agility and speed and situations of skill (Tendulkar et. al., 2018). In a study that is germain to the Athlete B endurance based athlete, with Type I dominant genetic composition, a study was conducted with endurance athletes/ marathon runners, conducting plyometric training for four weeks. After these 4 weeks, the results yielded significant improvements in their reactive strength index and their 2-kilometer time trial at a high altitude as opposed to their pre-test training at sea level. The experimental group showed better reactive strength index levels and the 2-kilometer time trial after the plyometric training as compared to the control group. Pursuant to this study, it was revealed that plyometric training is conducive to explosiveness and improved endurance capacity at sea levels and also as an aid to those who have been exposed to higher altitude training (Andrade et al., 2018). Lastly, proper and precise exercise prescription is necessary when it comes to developing strength and muscular power. The need for muscular power is sought after by elite athletes in order to achieve optimal athletic performance, to the elderly looking to prevent musculoskeletal breakdown (Kraemer et. al., 2000).

Balance Training

Balance training is training that incorporates strengthening the muscles in the body by centering the focus of the effort on the legs and the bodies core. Collectively, these muscle groups give the body the ability to develop a strong posture and keeps it stable. When the body has good balance, it enables the individual to efficiently move through their daily activities, whether it may be walking, bending over to get in a chair or leaning over to put on your shoes. When an individual has a good sense of balance, they will have the ability to maintain their center of gravity. Therefore, the athlete will achieve optimal proficiency in their training depending on how well developed their balance is. There are many types of training to develop and maintain balance and they can range from relatively easy to extremely difficult based upon the intensity utilized during the training. Some of these balance training exercises include: raising one leg or knee while firmly planting the other on the ground and holding this position for at a minimum of 10 seconds, alternating knee raising while walking forward, yoga training, or even using stabilizing equipment such as Bosu balls and/or balance boards. Just like resistance or endurance training, balance training will be improved based upon the volume incorporated into the program. Therefore, incremental steps to improve balance will include holding the actual drill position (such as the knee raise) for an extended period of time, eye closure or incorporating a physical move to the exercise, such as raising the opposite arm of the lifted knee (Watson 2020). Balance training can be conducted on an everyday basis as it is not critically demanding on the body and the musculoskeletal system but some studies have shown that even as a few days per week has positive effects in improving performance.

The athlete that focuses on “balance’ training does so in order to improve their balance, posture and prevent injury. There is not one certain and definitive type of balance training that is the model approach. Based upon a meta-analysis of 36 studies, a conducive or positive result based program to develop balance would be up to 2 training sessions per week, and a single training session of 45 min (Brachman, et. al., 2017). Balance training exercises can be completed on both “unstable” and “stable” surfaces. One study, comprised of 54 basketball players were prescribed for a 22-week basketball specific balance training program in order to determine the incidence of ankle sprains. This training was for 3 times a week and lasted in duration of 5 to 10 minutes with a progressive increase in the difficulty of the exercises. Posttest results revealed a meaningful significant 95 percent decrease of lateral ankle sprains as compared to the control group. Therefore, this study illustrated the need of balance training as a preventative measure for ankle sprains (Cumps, et. al., 2007).

In Danoff, the effects of multiaxial and uniaxial unstable surfaces were designed in a program for Division 1 college athletes in sports that have a high propensity for ankle sprains. The 36 athletes were selected from soccer and volleyball and the uniaxial unstable surface was a rocker board. The multiaxial balance training was conducted on a dynadisc. The test consisted of balancing on one leg on either of the training platforms mentioned and subsequently catching a 1 kilogram ball. This balance training was conducted 3 times a week and continued for 4 weeks. It was revealed that there was a significant difference from pre- to posttest as the significance was measured through the Star Excursion Balance Test or SEBT (Danoff et. al 2010). The SEBT is a dynamic balance test that measures strength, proprioception and flexibility. This study revealed that a high level of balance training is needed for athletes during the off-season and furthermore that ankle sprains in athletes have been mitigated by balance training of involuntarily increasing joint stiffness while exercising in a unstable situation (Danoff, et. al., 2010).

Lastly, a study focused on evaluating the cost effectiveness of training through the use of a proprioceptive balance board in order to prevent ankle sprain injuries was conducted through the use of 116 volleyball players during the 2001-2002 season. There were one 1,122 volleyball players between the intervention and the control group. The program design for the intervention group was utilizing the balance board during their warm-up routine in order to prevent cost expenditures for ankle injuries. If the athlete suffered an ankle injury, a diary was kept detailing the cost of the treatments. After comparing the 2 groups on a cost analysis, it was learned that although those in the intervention group were higher, the actual long-term prognosis for those in the intervention group to not suffer future ankle injuries were a lot lower and ultimately were more cost effective for the program. (Verhagen, et. al., 2005).

During balance training, it is critical to identify the weaker components in the chain which prohibit gains in power, agility, strength and speed. It is through the correct assessment of these weaknesses that they can become personal strengths.

Flexibility Training

Flexibility training is the ability to develop multiple degrees of differing movement ranges in the bodies joints. This can be accomplished both with and without the use of equipment or a training partner. The athlete can move in a better range of motion for their respective sport by having a greater degree of flexibility and this can contribute to strengthening of the bodies muscle tissue.

The stretching of a muscle fiber begins with the sarcomere, and the overlapping area between thin and thick myofilaments increases. As the stretch elongates, the overlap area decreases and the muscle has reached its ultimate length of rest. The additional stretching at this point puts tension on connective tissue. The connective tissue assimilates with the tension and the actual muscle fiber gets pulled back to its original sarcomere position. The connective tissue then makes up for the slack that was created by the fiber returning to its original position. When the muscle is stretched, some fibers stay at rest but the working fibers elongate or lengthen. The actual length of the muscle is then dependent upon how many fibers are stretched (MIT 2019). This is important because when a muscle is stretched and lengthens, it can have many beneficial effects for the athlete. Whether the athlete is Type I dominant or Type II dominant, a lengthened muscle will give the athlete a greater range of motion. A greater range of motion is important for the athlete as it enables them to achieve through better performance. Better performance will be achieved through improved mechanics which in turn yields competing at a higher level. Better flexibility also improves blood circulation and neuromuscular coordination.

Flexibility training can be performed either prior to, or after the athletes training. There are some schools of thought that advocate for a totally separate program design of flexibility training independent of the regularly scheduled workout. When stretching before, the body should be warmed up through a minimal intensity endurance exercise such as a light jog or brisk walk for approximately 3 minutes. If performed after training, the stretching routine can be a little more tasking. There are several types of flexibility training and they include: dynamic, ballistic, static, proprioceptive neuromuscular facilitation (PNF), isometric, relaxed or passive and active stretching. These stretches, depending on the type chosen, should be conducted or held from between 30 to 60 seconds (Acosta-Laureano 2010). If dynamic flexibility training is chosen, it will closely mimic the physical moves that the athlete will make in their chosen sport during competition and will raise the athletes heart rate to prepare more precisely for that respective sport. The dynamic drills which include muscular movement, are critical for optimal athletic performance, whereas static flexibility is the ability of the joint to move passively though a range of motion and prepares the body to avoid injury as it is stretched beyond its usual limitations. PNF stretching combines the benefits of both building strength and flexibility. This stretching utilizes alternating ten seconds of contraction and relaxation for at least four sets at increasing joint angles. PNF uses receptors in the nervous system present at the intersection of the muscle-tendon point called Golgi tendon organs which are susceptible to variations in muscle length and muscle tension. Flexibility exercises are to be included to encompass an exercise program consisting of endurance exercise, resistance training, and neuro-motor exercise training. It is unknown whether flexibility or stretching should be conducted pre- or post workout, however, flexibility exercises as a separate program to assist the athlete in achieving optimal athletic performance is something to be considered (Bushman 2016).

Injury Prevention

Injury prevention for the athlete can be accomplished by the coach or athletic trainer educating the athlete on how to reduce the risk of injury and show corrective measures on how to properly utilize training equipment for gaining strength, power, speed and balance. Some examples of this are pre-season conditioning for the particular sport. Adding small incremental changes to the workout program and always conducting a warm-up before the training session begins and using good technique will ensure that the athlete is taking the necessary precautions to be injury free. The correct supervision and the precise implementation of teaching an athlete on how to use the proper equipment should be done by a qualified fitness professional. Either the athletes coach, athletic trainer, personal trainer or more appropriately, a certified strength and conditioning specialist (CSCS) through the National Strength and Conditioning Association (NSCA) would be optimal to give the athlete a firm foundation of correctly using all types of training equipment.

Injury prevention also encompasses balance and flexibility training. As mentioned above and the various stretching types, the two most dominant ones are static and dynamic stretching. Static stretching, in which the muscle is lengthened for a set amount of time on one plane of motion with the individuals body weight or opposite muscles, was the favorite form of stretching for several years. Static stretching improves flexibility and range of motion. Recently, static stretching has been re-evaluated prior to exercise as it may possibly decrease muscle power and strength which therefore is negative for the athlete. However, dynamic stretching, is the mimicking or exaggerating the utilized muscle through the ranges of motion that the athlete will perform during exercise. They are not performed at full speed but at a much lower intensity to warm the muscle up. This is conducive for muscle performance and beneficial for the athlete as the muscles are thoroughly stretched in the normal movement patterns that are to be subsequently used. Dynamic stretching, because of this, will elevate the bodies core temperature, elevate overall temperature of the muscle and the bodies central nervous system as it engages the body in total muscular control and coordination. Of all the injuries incurred by the football players, the injury to the knee is the most commonly occurred injury. This study illustrated that 54 percent of the athletes in a previous NFL combine had suffered a knee injury. 25 percent of the athletes had a cumulative total of 114 surgeries. Out of all the knee injuries, the medial collateral ligament was the most injured. Knee injury history was highest among defensive linemen at 68 percent, and tight ends and offensive linemen at 57 percent, however actual surgery was more predominantly performed on running backs at 36 percent and linebackers at 34 percent. Overall, one fourth of the players that had sustained a knee injury had a surgical procedure conducted (Honkamp, et. al., 2008). Athletes with injuries such as this have to be very cognizant of specific guidelines to enable them to return to their previous level of performance. Some of these factors include a precise rest and recovery period without a rush to return to the athletic environment because of pressure from external, media and societal pressures. The recovery process can take anywhere from two to six months but the ability to return to a pre-injury condition, the recovery period can take up to nine months. This is a viable timeframe which includes stability and a full range of motion. However, this also depends on the individual athlete and how well they focus on their physical therapy and then strength and conditioning routine for a successful recovery.

A meta-analysis study was conducted of 400 reviewed articles in which 15 were selected in order to determine whether or not running related injuries were more attributable to males as opposed to females. This study revealed that women were less susceptible to incur injuries as a result of long distance running. Stronger evidence also dictated that those with previous injuries and those that have used inserts in their running shoes, were more prone to additional running injuries. Some of the variables that increased injury use for women were using the same shoes for 4 to 6 months, running 30 to 39 miles per week, running marathons and running on a concrete surface. Some of the variables that increased injury use for men were inexperience in running for up to 2 years, weekly running distances of 20 to 30 miles and having a weekly distance of over 40 miles (Van der Worp, et. al., 2015).

The Tactical Athlete

Advancements within the strength and conditioning field since 2005 with training the professions of law enforcement, military, firefighters and others in the emergency service field has come about and has labeled these first responders as “tactical athletes.” The premise behind the tactical athlete is to train them in order to produce optimal physical athletic ability and performance enhancements based upon scientific principles and procedures in order to make them ready for duty. The training is designed to work the cardiovascular system though aerobic and anaerobic means through the recruitment of Type I and Type II muscle fibers. Since these professions demand a high aptitude for performing physical movements that require strength, power, speed and agility, the tactical athlete is trained performing functional movements that ultimately increases productivity in the field by being ever ready when called upon in the line of duty. The National Strength and Conditioning Association (NSCA) has added a certification in which it calls this certification holder professional a Tactical Strength and Conditioning Facilitator (TSAC-F). This program has assisted those in the law enforcement, military and firefighter fields to not only increase their productivity in their respective field but through a financial outlook, it has assisted in lowering medical costs through these scientifically designed research, training methods and knowledge incorporated into the program from the field (NSCA 2020).

Additionally, the United States Army has adopted this type of training and has created their own brand of this philosophy and has implemented it as Mission Essential Fitness or M.E.F. Because of the demands of the military field, a complete and overall fitness routine is paramount to develop the soldier for the demands they are faced when in theatre or deployment. An 8 week, 15 session study was conducted by the United States Army in which they looked to see the effectiveness of a M.E.F. style functional fitness, circuit training as compared to the standard Army Physical Readiness Training (APRT) and the results on overall fitness and changes in body composition. 34 subjects were included in the M.E.F. group and 33 subjects were in the APRT group. The program design for the M.E.F. group included functional movements geared towards power, speed, strength and agility and these exercises were conducted for 60 to 90 seconds, with a cumulative total workout time of 45 minutes. Pre-test, baseline measures were assessed for the traditional Army physical readiness exam, physiological assessments and body composition. Post-test results illustrated that the M.E.F. participants in comparison to those in the A.P.R.T group, had significant gains in push-ups, bench press and flexibility. Therefore, this study demonstrated that the M.E.F. training program effectively produced muscular strength and endurance, flexibility and cardiovascular endurance through the use of a functional fitness design program which was devised through a circuit style of training (Heinrich, et. al., 2012).

Mission Essential Fitness

TABLE II. Between-Group Comparisons for Changes in APFT, Physiological, and Fitness Variables

Change in Variables	MEF mean (SD)	APRT mean (SD)	F statistic	*p*-Value
APFT				
Change in Push-Ups	4.2 (5.4)	1.3 (5.9)	4.761	0.033
Change in Sit-Ups	0.7 (4.9)	−2.3 (4.9)	2.778	0.120
Change in 2-Mile Run time (Seconds)	−83.9 (70.2)	−15.3 (69.2)	9.992	0.003
Physiological Indicators				
Change in Systolic Blood Pressure	−7.7 (16.1)	−3.4 (11.8)	1.196	0.278
Change in Diastolic Blood Pressure	3.4 (16.7)	0.6 (13.5)	1.446	0.234
Change in Resting Heart Rate	−6.0 (11.6)	−3.0 (11.7)	0.380	0.540
Change in Basal Metabolic Rate	−22.85 (197.60)	42.39 (324.14)	1.017	0.317
Change in Relative VO_2 ($mL \cdot kg \cdot min^{-1}$)	2.39 (5.93)	1.24 (2.40)	0.568	0.455
Other Fitness Tests				
Change in Step Test Heart Rate	−17.0 (15.0)	−9.0 (16.1)	8.839	0.004
Change in Vertical Jump (in)	1.2 (1.9)	0.7 (2.4)	0.750	0.390
Change in Broad Jump (in)	3.0 (13.4)	−0.9 (3.5)	2.469	0.121
Change in Agility	−0.2 (0.4)	−0.2 (0.3)	0.099	0.754
Change in Bench Press (Pounds)	13.2 (12.1)	2.7 (11.5)	12.933	0.001
Change in Flexibility (in)	0.6 (1.3)	−0.5 (1.6)	9.729	0.003

Baseline values were used as covariates.

Figure 6: Variable Changes Between M.E.F. and APFT (Heinrich 2012).

During this training, the program design of exercising different muscles through functional movements essentially recruits additional motor units, which are functioning units of the neuromuscular system. They are comprised of the alpha motor neuron and its call to action of the muscle fibers. This motor un it can innervate/supply less than ten muscle fibers for small muscles or more than one hundred fibers for powerful and significantly larger muscles in the trunk and limbs. When the individual is exerting maximal force, total recruitment of all muscle fibers will be effected. Therefore, it is these gains in maximal strength as depicted in Figure # 6 above that agonist muscles illustrate these benefits through a recruitment increase of the motor units, increase firing rate and improved coordination of neural discharge (Haff & Triplett 2016, pg. 89).

Mission Essential Fitness and the United States Army

Currently, the United States Army utilizes the Mission Essential Fitness Program at Ironworks Gym East located at the Fort Bliss, El Paso, Texas military base. This program, devised under the Human Performance Section, is led by NSCA Certified Strength and Conditioning Specialists (CSCS). As noted above, these exercises are designed to focus on developing and optimizing strength, power, speed, agility, through various degrees of movement of the soldier through a functional circuit style training. The circuits are currently comprised of 30 stations of which 5 soldiers perform simultaneously at each station for a total of 60 seconds per exercise and a 30 second rest, and then subsequently move on to the next program designed station. The entire M.E.F. exercise program takes 45 minutes. The enclosed facility is equipped to handle a minimum of 150 soldiers, however, depending if the soldiers exceed that amount present, then additional accommodations will be made available with additional stations for the soldiers outside but yet adjacent to the facility. This had recently been the case recently in January 2020 in which another 100 soldiers trained at the outside exercise stations, which brought the approximate total trained at this M.E.F. facility to 250. It is this type of functional training that places primary focus on the development and refinement of Type II A and Type II B fast twitch muscles in order to train the soldier as a tactical athlete.

The M.E.F. Program because of its functional style program and high intensity design, will recruit energy primarily from two of the three energy systems of the human body. The three energy systems are the phosphagen, glycolytic and oxidative systems. These energy systems, which rely on adenosine triphosphate or ATP as the universal transporter of energy in the cell, combine with phosphocreatine or PC to produce muscular contraction on a very short amount of time or less than five seconds. This is the phosphagen energy system. Therefore, the phosphagen energy system will be called upon by the tactical athlete as well as the recruitment of Type II muscle fibers. The next energy system, the glycolytic system, produces energy quickly from ATP also, without the recruitment of oxygen but by the systematic degradation of glucose in order to form two molecules of lactate. (Powers et. al., 2015, pgs. 49-50). Muscular contraction is produced during this process also and can be for less than 2 minutes. Therefore, the glycolytic energy system will be called upon by the tactical athlete as well as the recruitment of Type II muscle fibers. Lastly, the oxidative energy system is the third energy system and utilizes ATP with the assistance of oxygen for long term low intensity exercise that lasts for over two minutes. Therefore, the oxidative energy system will be called upon by the tactical athlete for anything that requires recruitment of Type I muscle fibers. Because of the inherent nature of the M.E.F. and its high intensity format, this energy system will not be recruited because of the timeliness and duration of this program's design.

Chapter 4 Discussion

Based upon the relevance of the results indicated in the studies presented in this capstone, it has been illustrated that in order to achieve optimal athletic performance for the athlete or an individual, it is best to train within the exact genetic makeup within that person's body composition. These studies that were set forth had explained how they compliment what was researched in the literature review. The research had indicated that humans have their own genetic makeup and composition and the human body can be made up of either Type I or Type II A or Type II B muscle fibers. These fibers are slow twitch (Type I), and fast twitch (Type II A and Type II B). These fibers, depending on the individual, will enable them to perform better in certain athletic events as opposed to others. Within this paper, it was shown how Type I fibers, or slow twitch fibers are found in greater abundance in long distance endurance based athletes' and thusly those were better equipped to perform in those types of events. These individuals had a higher oxidative energy capacity and were thusly able to excel in their chosen sport for that reason. On the other side, Type II A and Type II B muscle fibers, or fast twitch fibers are discovered in greater abundance in athletic events that require strength, speed and great amounts of force production. Those that exhibit these characteristics tend to perform in such events as the

100 and 300 yard dashes, powerlifting or football. These sports rely primarily on the phosphagen and glycolytic energy systems for their stored energy to excel in their respective sports.

Chapter 5 Conclusion

In order for an athlete to achieve optimal athletic performance or for an individual that desires to achieve a better degree of physical fitness, it is critical that they design a program based upon genetically-determined fiber typing. The human body is composed of skeletal muscle which contains muscle fibers. The two types of muscle fibers, slow twitch or Type I, or fast twitch, Type II A or Type IIB, are the muscle fibers that are called upon in everyday normal movements but also during exercise. In order for the athlete or individual to excel or achieve optimal athletic performance, that individual needs to be cognizant of their own genetic makeup of their muscle fibers. Once this is known, that individual, with the assistance of a fitness professional, can assess, devise, evaluate and implement a program design that will benefit them to bring about the goals and vision that they have for the optimal fitness and performance. Many scientific backed studies in program design have discovered results that the force production that is needed in certain athletic activities are recruited at a higher rate of exertion through the recruitment of Type II A and Type II B muscle fibers. Additional studies have also illustrated results that a lower rate of force production is necessary, but a higher rate of oxidative capacity is called upon during the recruitment of Type I muscle fibers. Therefore, in program design it is essential that the fitness professional has the athlete or the individual using a proper program design that is specifically geared towards the recruitment of the exact muscle fiber types that their body needs for optimal performance. The primary program design can be through resistance, concurrent or endurance based training. Furthermore, a proper program design that includes plyometric, balance, flexibility and injury prevention training will not only aid in the strengthening of those Type I, Type II A and Type II B muscle fibers, but will also contribute to improved athletic performance. A relatively new concept in training the first responder community of law enforcement, firefighter and the US Military has come about in which the National Strength and Conditioning Association now offers to provide those in these professions tailor made program designs for those entities as tactical athlete's. It is because of the inherent nature and the physically demanding situations placed upon the law enforcement, firefighter and military community that these individuals need to be ready for duty in whatever situation they face. This thinking has changed theories of how the tactical operator is best fit to serve the community as the tactical operator needs to be able to function in not just the sagittal, but also on the frontal and transverse planes. These planes anatomically divide the body to illustrate the necessity of training the tactical athlete in various functional movements. Whether these situations are calling upon the tactical operator through a strength and conditioning or an endurance based perspective, these tactical athletes are being trained for those exact circumstances and situations. Furthermore, this type of training is also excellent for neuromuscular control of the body, prevent chronic overuse, can be pre-emptive and assist in alleviating traumatic and/or overuse injuries. If someone is engaged in the same program design of working the same muscles on the same weekly basis and in only one plane, they will be more susceptible to chronic abuse which can result in traumatic injury such as rhabdomyolysis. If the tactical athlete trains in this way, they are working different muscles on different days of the week which builds a firm base to be ready to be called upon in the tactical arena.

Currently, the Mission Essential Fitness Program under the Human Performance Section at Fort Bliss, Texas, is one such program that is successfully training the US Army through the proper recruitment of the exact muscle fiber type and energy system that will improve them physically for optimal athletic performance.

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