

**Effects of Eccentric Training Intervention on Performance During the  
Sprint, Drag, Carry Event of the Army Combat Fitness Test**

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## Table Of Contents

Abstract.....	5
Chapter 1: Introduction: .....	6
Purpose of the Study.....	8
Specific Aims and Hypotheses .....	8
Limitation and Delimitations.....	9
Chapter 2: Literature Review: .....	10
Introduction .....	10
Army Combat Fitness Test .....	11
Sprint Drag Carry Event.....	12
Injury .....	14
Eccentric focused training.....	16
Nordic Hamstring Exercises: .....	18
Chapter 3: Experimental Protocol: .....	25
Participants, Inclusion, and Exclusion Criteria, and IRB Approval .....	25
On-boarding .....	25
Pre/Post Testing.....	26
Sample and Effect Size .....	28
Data Analysis.....	29
Chapter 1-3 References .....	30
Chapter 4: Journal Manuscript .....	37
Introduction .....	37
Methods.....	38
Experimental Approach to the Problem .....	39
Subjects.....	39
Table 1. Participant demographics separate by groups.....	40
Procedures .....	40
Figure 2. Sample Training Week .....	42
Statistical Analysis.....	43
Results.....	43
Table 2. Treatment ACFT Event Scores and Overall Score Changes .....	44

Table 3. Combined ACFT Event Scores and Overall Score Changes.....	44
Discussion.....	45
Practical Application .....	48
Manuscript References .....	49
Appendix A: Informed Consent.....	56
Appendix B: Investigator Script.....	64
Appendix C: 2020 PAR-Q+ .....	70
Appendix D: Injury History Questionnaire .....	74
Appendix E: Subject Demographic/Training History Survey.....	76
Appendix F: IU-HSU-Protocol.....	77
Appendix G: Borg Scale Handout .....	87
Appendix H: Data Collection Sheet .....	88
Author’s CV .....	90

## Abstract

The purpose of this study was to determine the effect of introducing eccentrically focused movements into a normal Military training program on the Army Combat Fitness Test (ACFT). The fourth event of the test, the Sprint Drag Carry, was the focus of the research. Eccentric training has been shown to elicit a sprint performance benefit<sup>10,13,19,27</sup> as well as decrease injury prevalence<sup>17,20,28,34,36</sup>. It was hypothesized that including eccentric movements would improve performance for this 250m shuttle sprint event. Twenty-two Cadets from the Indiana University ROTC program were recruited to participate in a 6-week training program. Participants were randomly assigned to one of two groups to conduct either 3 x 5 repetitions of a Nordic Complex (combination of Nordic hamstring curl and reverse Nordic hamstring curl) or 3 x 15 repetitions of a tempo-based body weight squat. Participants took a pre and post ACFT to measure the change in performance. Overall ACFT scores as well as three of the six events showed significant improvement; 3.1% ( $p < .001$ ) improvement in overall score (out of 600), 6.7% ( $p = .001$ ) improvement in Hex bar deadlift, 2.7% ( $p = .045$ ) improvement to 2-mile run time, and 10.4 % ( $p < .001$ ) improvement in Sprint Drag Carry performance from pre to post with no differences between groups. No injuries were reported during the training period. The results demonstrate there was an observed improvement from pre to post-test; however, it is more likely a result of a dedicated training program designed by the Army to improve ACFT performance than the addition of the movements.

## Chapter 1: Introduction:

Soldiers enlisted in a modern military are required to be tactical athletes. In recent years, the military has designated money and resources to improving the efficiency of Soldier training and provided information for enduring the holistic mission. However, the military is still in its infancy as far as fully implementing a sustainable plan to not only optimize Soldier performance but continue to reduce injuries that have plagued the military for decades. Musculoskeletal injuries (MSI's) continue to be not only an issue to unit readiness but a deep financial hole in the government's pocket due to the amount of disability as a result of injuries sustained during service.<sup>18</sup>

Musculoskeletal injuries are not only the leading cause of injury for military service members but are 2-3 times greater than the next leading category (mental illness).<sup>36</sup> In 2006 alone, there were over 743,500 injury-related musculoskeletal conditions. The leading causes of observed injury-related musculoskeletal conditions were classified as inflammation/pain (overuse) (82%), followed by joint derangements (15%) and stress fractures (2%). The knee/lower leg (22%), lumbar spine (20%), and ankle/foot (13%) were leading body region categories.<sup>14</sup> Injury trends remain consistent, as demonstrated in the 2019 Army Medical Surveillance report stating overuse injury continue to constitute 72% of all new injuries.<sup>14</sup> It is imperative that military leaders train their Soldiers with the same dedication to injury prevention as they do to performance.

To address Soldier injury rate affecting readiness, the Army rolled out their new "Army Combat Fitness Test" in 2019. The ACFT was the first new test in over 40

years.<sup>34</sup> The 6-event test consists of a maximum 3-repetition hex bar deadlift, a standing power throw with a 10lb medicine ball, the sprint-drag-carry event, which is a 250-meter shuttle that includes sprinting, dragging a 90lb sled, side shuffling, hand-carrying two 40lb kettlebells, and finally sprinting again. The 5<sup>th</sup> event is the maximum effort plank, and finally the test finishes with the classic 2-mile run. The ACFT was developed to not only assess the aerobic muscular endurance on Soldiers, but also the anaerobic power output in explosive movements.<sup>13,34</sup> The new movements have come with a risk of an increase in musculoskeletal injuries. Proper exercise selection and program progression will need to be addressed in order limit MSI's as the Army places emphasis on the ACFT.

One recommended modality to improve muscular strength and reduce injuries in the low back and lower extremities is eccentric training. The concentration of the eccentric phase of movements has been shown to increase fascicle length and cross-sectional area in addition to being a potent stimulus for enhancements in the muscle tendon unit.<sup>10</sup> Aside from increasing strength, an additional risk factor associated with lower extremity injuries in the lack of symmetry of hamstring and quadriceps often referred to as the H:Q ratio.<sup>10,32,33</sup> In order to maximize the benefit of the eccentric training on the lower extremity equal focus must be given to the posterior and anterior chains. The Nordic hamstring curl is a common eccentrically focused exercise aimed at developing the posterior chain, by combining the exercise with the Reverse Nordic Curl, which focuses on the quadriceps and hip flexors, a Soldier can achieve symmetry in their training goal. The aim of the study is to analyze the effects of an eccentric training intervention over a normal 6-week military training schedule for Army ROTC Cadets.

We will measure the change in performance characterized by the change in time to complete the sprint-drag-carry event of the Army Combat Fitness Test at the beginning and end of the 6-week training protocol with two modes of eccentric training intervention the Nordic Complex and the tempo body weight squat.

### *Purpose of the Study*

The purpose of this study is to observe if a 6-week eccentric based training intervention can have an impact on the overall time to conduct the Sprint Drag Carry event of the Army Combat Fitness test. The primary aim is to improve performance measured by a reduction in the overall time to conduct the event. The hypothesis is that those subjects that participate in the Nordic Complex group will have the greatest improvement in overall performance measured. The secondary aim of the study is injury prevention. The hypothesis is that those who participate in the Nordic Complex group will have a lower observed rate of injury during the intervention period.

### *Specific Aims and Hypotheses*

#### **Aim 1:** Improve performance

The researcher hypothesizes that the subjects within the NC group will complete the event with a lower overall time on the SDC than the squat group.

#### **Aim 2:** Reduce risk of injury (MSI)

The hypothesis is that those who complete the Nordic complex intervention will have a lower observed rate of injury than subjects in the squat group

### *Limitation and Delimitations*

Limitations to the field study include contributions to improvements during a regimented six-week training program. Cadets will be training three times a week regardless of intervention. Any significant improvements could be a result of a dedicated fitness regimen not otherwise conducted by college students. The testing site for pre and post will be conducted on the same surface type (turf) and will be conducted at the same time of the day (0530-0700). The 2-mile track during pre-testing will be conducted on a 400m track and the 2-mile posttest will be conducted on a <3% grade course of asphalt. The cadets understanding of the Borg scale of perceived exertion could limit the validity of some of their feedback. All recording equipment (timers, scales, stadiometers) are calibrated; however, hydration status during pre and post body fat percentage data collection could impact the resultant percentage.

## Chapter 2: Literature Review:

### *Introduction*

Beginning in 1858 at the United States Military Academy at West Point in New York, the United States Army began issuing a physical fitness test to cadets to assess their physical capabilities. The first test included a 15-foot wall climb, 15-hands high horse vault (5 foot), 10-foot ditch leap, 1 mile run under 8 minutes, or 2 mile run under 18 minutes, 4.5 mile walk in 1 hour, 3-mile ruck in 1 hour with 20-point ruck with arms and equipment.<sup>34</sup> The tasks were chosen to assess the needs of the Soldiers at that time. Since 1980 the Army has operated under the Army Physical Fitness Test which included maximum repetitions of push-ups in two minutes, maximum repetitions of sit-ups in two minutes, and lowest time possible on a two-mile run. The APFT was meant to measure the aerobic endurance of the upper and lower body muscle groups. The design of the Army's physical fitness program was to create lean, fast Soldiers; however, once the Army started issuing body armor in the 1980s the typical outfitted combat Soldier could be carrying up to 50lbs of gear in various configurations in a combat situation.<sup>13</sup> Body Armor can constitute on average up to 21% of the total load carried by Soldiers and while body armor has improved resistance to life threatening injuries it has increased the number of extremity injuries.<sup>29</sup> The increase in load carried created a need for a much more durable Soldier who could move under constant load. A meta-analysis conducted by Kollock et al. attempted to determine if lower extremity muscle strengthening should be included in military knee overuse injury prevention programs by analyzing studies that had an uninjured and injured group, that reported means and standard deviations for the uninjured and injured groups and clearly

identified the test muscles and knee injuries.<sup>7</sup> After analysis, it was concluded that there was a much lower muscular strength observed in the injured group than in the uninjured group, especially in the hip flexors and adductors.<sup>7</sup>

Since 1980, the Army has seen conflicts shift to a more complex and dynamic theatre. Soldiers are now considered tactical athletes whose ability to produce force and rapidly recruit muscle units is just as important and low-intensity prolonged endurance tasks. It is becoming increasingly important to develop Soldiers as early as possible considering the number of Soldiers who come into the military with a background in any fitness related activities has decreased and the injury rate during initial entry training has increased. Approximately 25% of male recruits and 50% of female recruits sustain a musculoskeletal injury during initial training.<sup>25</sup> Musculoskeletal injuries cost the department of defense more than \$1.5 billion per year.<sup>29</sup> Almost 75% of Americans their age are not qualified to serve at all. According to a 2017 pentagon report, 71% of Americans between the ages of 17 and 24 years of are ineligible to serve in the military, with obesity as the largest contributing factor.<sup>4</sup>

### *Army Combat Fitness Test*

As a result of changing conditions, the Army realized the need for a new physical fitness test. In 2013, a proposal was given to Ft. Eustis, VA to create a new test to assess Soldiers combat fitness level.<sup>13</sup> The test was to be based on a set of Warrior Tasks and Battle Drills used to assess Soldiers combat readiness. The process yielded the six-event Army Combat Fitness Test. The six-event test included maximum 3-repetition deadlift, standing power throw, Sprint-drag-carry, leg-tuck, and 2-mile run.<sup>13</sup> The test was field tested by the Army Training and Doctrine Command and introduced

in 2019 as the new Army test of record. Unfortunately, before it was fully implemented on record, the COVID-19 pandemic struck, and units were unable to conduct in person Physical Training and the requirement for a passing physical fitness test was suspended.

The Army then contracted the RAND Corporation to use the data previously collected to conduct an analysis to ensure the test was meeting the efficacy desired to assess Soldier readiness. Upon completion of the study, it was concluded that the test itself still had some flaws. The “one-standard” nature of the test created unrealistic expectations and did not accurately consider the biological differences between males and females as well as the degrading abilities of older Soldiers. The Leg-tuck event did not accurately assess the lower abdominal endurance and became the most failed event.<sup>13</sup> As a result of the study, the Army revamped the test and rolled it back out on 1 April 2022 as the ACFT 3.0. The test remained a six-event test with the maximum effort plank substituting the leg-tuck as the test for core endurance.<sup>13</sup> The new test was once again a gender and age-dependent scored test.

### *Sprint Drag Carry Event*

The sprint-drag-carry event is the fourth event in the ACFT and is a measure of muscular power, endurance, strength, and anaerobic capacity. All movements are required to accomplish high-intensity combat tasks in durations lasting from seconds to minutes. The test is an assessment of the Soldier's capacity to react quickly to direct and indirect fire, build fighting positions, and even extract casualties from vehicles and move them to a safe location. It involves a 250-meter shuttle that breaks down into ten 25-meter segments. The event begins with the Soldier in a prone position with their

head, hands, and body behind the starting line. On the command “go,” the Soldier will pop up and begin sprinting down their assigned lane to the 25-meter line. The soldiers must touch the line with their hands and foot and then sprint back to the starting line. Once they reach the starting line, they will grasp the handles of the 90lb sled and begin dragging the sled back down their lane. They will pull the sled completely past the 25-meter line and then drag it back to the starting line. Once the entire sled crosses the line the Soldier will conduct a lateral shuffle back down their assigned lane until they reach the 25-meter line. Once at the line, they will touch with their foot and continue the shuffle back to the starting line. Once they reach the starting line, they will grasp two 40lb kettlebells, one with each hand, and move quickly down their lane to the 25-meter line. Once at the line, they will cross and move quickly back to the starting line continuing to carry the kettlebells. Once they reach the starting line, they will place the kettlebells down and conduct an additional sprint down and back. Time for the event will stop once the Soldier crosses the starting line.<sup>13</sup>

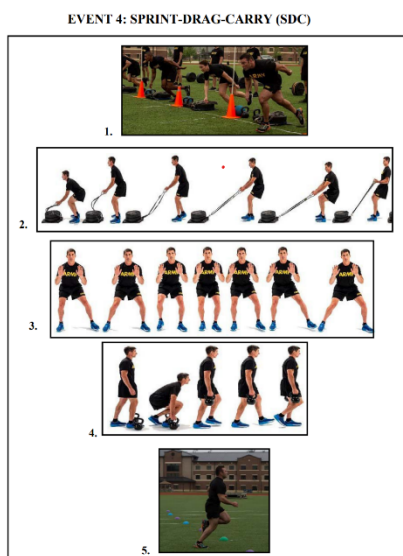


Figure 6: SPRINT-DRAG-CARRY (SDC):  
1. 50m Sprint 2. 50m Sled Drag 3. 50m Lateral 4. 50m Kettlebell Carry 5. 50m Sprint

While the sprint drag carry event could be a suitable method for assessing a Soldier's anaerobic fitness, its dynamic nature may contribute to injuries during the testing process. Starting with the requirement for rapid force production, a Soldier must attempt to reach the highest velocity possible within 25-meters and then quickly decelerate to change directions. The process of rapid force production and activation has been shown to lead to muscle strains.<sup>17</sup> In an analysis of the influence of hip-flexion angle on hamstring injuries Guex et al reported 50% of all muscular injuries associated with sprinters are hamstring strains most prevalent in the biceps femoris and at the terminal stage of the swing phase of gait.<sup>12,16</sup>

### *Injury*

The very nature of military training increases Soldiers' risk for lower extremity acute and overuse injuries. During a 9-week shoe characteristics study at West Point, over 800 cadets were assessed during an intervention of typically prescribed military training prescribed to all cadets at the academy and other new Army recruits. The researchers observed that over 18% of the cadets sustained at least one lower extremity injury during 9-week training.<sup>15</sup> This demonstrated that it's not just the untrained population that are experiencing these injuries. West Point cadets are required to undergo a Cadet Fitness Assessment prior to applying and are usually a more fit population. The focus in the Army's injury mitigation needed to target training programs to help reduce the rate of MSI's.

TABLE 1  
Injury Diagnosis Within Each Region (n)

Lower Back	Hip	Thigh	Knee	Shank	Ankle	Foot
Lower back pain (5)	Hip flexor tendinitis (4) Femoral shaft stress fracture (2) Greater trochanteric pain syndrome Gluteal tendinitis Inferior pubic ramus stress fracture Hip flexor strain	Hamstring strain (4) Adductor tendinopathy Adductor strain Quadriceps strain	Patellofemoral pain (29) Iliotibial band syndrome (9) Patellar tendinitis (5) Knee contusion (2) Medial patellofemoral ligament sprain Medial collateral ligament sprain Prepatellar bursitis	Medial tibial stress syndrome (17) Gastrocnemius strain (2) Tibial stress fracture	Lateral ankle sprain (37) Achilles tendinitis (2) Achilles tenosynovitis	Foot pain (6) Metatarsalgia (4) Great toe pain (3) Plantar fasciitis (3) Second metatarsal stress fracture (2) Cuboid subluxation Heel contusion

\*Injuries are followed by n value in parentheses. For injuries with no value in parentheses, n = 1.

Researchers have attempted to determine training protocols to reduce rates of common injuries in military populations. Carow et al. looked at implementing a Dynamic Integrated Movement Enhancement (DIME), a ten-exercise intervention aimed at preventing specifically knee injuries. During their research, they looked at injuries sustained during the initial summer training for new West Point cadets called Cadet Summer Training (CST), as well as injuries sustained throughout their first academic year. Injury rates of 14.9% during the Cadet Summer Training and additional 13% during the academic year. The primary injury risk during that period was ankle injury. While the overall rate of injury was not significantly reduced through the intervention, they did see a significant change in injury rate if the intervention was delivered by the cadre than by the upper-class students demonstrating a need for facilitation by those who are most qualified.<sup>7</sup>

The need to not only apply the correct methodology but proper implementation evident by Carrow's research is often overlooked when Soldiers are assigned training plans. Often untrained individuals are at a higher risk of injury when performing more complex movements without an adequate foundation of how to activate muscle groups in the right order which creates an inefficiency or incorrect motor firing sequence in the

posterior chain can also lead to injury. The proper firing sequence used in hip extension during sprinting for the posterior chain should be multifidus, which is a deep core stabilizer that attaches to your vertebrae, then the glutes, hamstrings and then calves.<sup>21</sup> If the glutes are delayed in activation because of inefficient firing sequence, it can not only decrease the efficiency of the gait but can also cause increased stress on hamstrings potentially leading to increased risk of injury. Bullock-Saxton suggests that gluteal activation and pelvic stability are often decreased in chronic low-back pain sufferers. Low back pain is often a complaint of military service members during explosive sprinting/climbing/dragging movements.<sup>6</sup> An improper training intervention not designed to assist Soldiers in activation patterns could lead to more low back pain and possible injury.<sup>6</sup>

### *Eccentric focused training*

A military training program must include considerations for injury prevention while also increasing a Soldier's performance and readiness. One proposed method that has shown benefits to not only reduce injuries but improve force development and overall strength is eccentric focused training.<sup>16</sup> Eccentric contractions are lengthening of the muscle-tendon complex.<sup>16</sup> Eccentric contractions occur when a force applied to the muscle exceeds the momentary force produced by the muscle itself, resulting in the forced lengthening of the muscle-tendon system while contracting.<sup>24</sup> Eccentric contractions are extremely important as they support the skeletal muscle's ability to stabilize the body's weight against gravity, absorb shock, and store elastic energy in preparation for concentric contractions<sup>20</sup>. Soldiers often move under heavy loads and one of the focuses of basic movement techniques taught at Basic Combat Training include 3-5 second bounds that are done with weapon and equipment such as ballistic

helmets and body armor.<sup>13</sup> The increase in attenuation of these additional masses would be beneficial to Soldiers especially without any experience. An acknowledgment of the importance of events that can test a Soldiers' ability to conduct these movements led to the addition of the Sprint Drag Carry event.<sup>13</sup>

The Army has recognized the importance for a soldier to redirect their movements quickly and has demonstrated this focus by including the SDC in the ACFT that requires Soldiers to go from peak velocity to stopping nine times during the event. As discussed earlier, the physiological toll that an event like the SDC has can lead to earlier onset fatigue because of inefficiency in energy regeneration. As a more efficient training modality, eccentrics can allow a Soldier to get more for their efforts. There are those that will argue that because of the nature of eccentric contractions there is a high incidence of Delayed Onset Muscle Soreness (DOMS) and that untrained subjects tend to lack the ability to fully activate their muscles during maximal eccentric muscle contractions.<sup>16</sup> The repeated bout effect (RBE) is a phenomenon that occurs when a repeated bout of the same or similar eccentrically biased exercise reduces markers of injury when compared to the first bout.<sup>22</sup> So while eccentrics do cause more skeletal muscle damage, (leading to eventual gains in strength) as compared to concentric contractions immediately following completion of the intervention, there is evidence that because of RBE, skeletal muscle can gain protection from mechanical injury even after repeated bouts.<sup>22</sup> The aim of the eccentric training would be to improve hip extensors and lower extremity muscle strength by increasing fascicle length and cross-sectional area within those supporting muscles and increasing knee flexors to improve maximum knee flexion without injury.<sup>3</sup>

### *Nordic Hamstring Exercises:*

There are several exercises that provide increased force development and activation, elongate muscle tendon units, and improve balance and coordination needed to stave off injury. Squats serve as an exercise to maximize hip/knee extension during the concentric phase and hip/knee flexion during the eccentric phase and can be scaled from body weight to any external load. The back squat is widely accepted as one of the most effective exercises to enhance athletic performance.<sup>28</sup> Squatting; however, has been identified as a strength exercise with a raised risk of injury for the lower limbs and the trunk compared to other strength exercises.<sup>23</sup> Aside from body weight, it can be logistically costly to provide equipment necessary to scale the movement appropriately to maximize its performance benefit and injury resilience. The high prevalence of lower back injuries within the military also makes it potentially a high risk-low reward training asset. There may be a more effective and safer exercise to provide progressive overload and create force development, increase activation, reduce injury, and train with minimal resources and intervention execution length. The Nordic Hamstring curl is a partner assisted exercise where the subject attempts to resist the external torque created by an individual's body weight using their hamstrings to maximize loading in the eccentric phase.<sup>26</sup> It is a closed chain movement that offers many of the same activation patterns as the squat without the danger of having to “ditch” a bar if the lift goes poorly.

The Nordic Hamstring Curl increases eccentric hamstring strength which is considered essential for sprint performance.<sup>27, 35</sup> When compared to other hamstring exercises the Nordic Hamstring curl elicited significantly higher EMG activity. Gurhan et al. selected participants near the same age group of ROTC cadets and analyzed %MVIC on which exercise of stiff-leg deadlift, unilateral stiff-leg deadlift, Nordic

hamstring curl, and ball leg curl had the highest activation utilizing surface EMG.<sup>5,11</sup> The Nordic Hamstring Curl had the highest activation of all four movements especially in the biceps femoris which are crucial for sprint exercises. Additionally, Monajatii et al. looked at the activation by knee angle and phase of the movement in both the Nordic hamstring curl and ball leg curl. The rate of force production or capacity to produce maximum voluntary activation in the early phase of contraction, was represented best during the Nordic hamstring curl.

The biomechanical requirements of the Nordic Hamstring causing a subject to resist gravity and control the trunk immediately upon descent requiring high levels of muscle activation early in the joint range of motion.<sup>11</sup> Gurham would suggest that the Nordic Hamstring exercise is extremely beneficial for hamstring strength development and can be a great tool for injury prevention. The ease of implementation and lack of equipment needed makes it a great tool for improvement for military Soldiers who are often in areas without complex equipment and machines who still need to maintain a high performance and reduce injury risk.

Early muscle activation during the execution of the Nordic provides rapid recruitment of the maximum amount of muscle units to elicit the highest possible velocity in the short sprint distances. Kommes et al conducted a study analyzing 30-m sprint trials for soccer players in where through a 10-week Nordic hamstring intervention he saw statistically significant improvements to both the 5m and 10m splits indicating improvements to the explosive characteristics of the sprint.<sup>19</sup> The observed improvements could translate to the explosive nature of the spring-drag-carry especially reducing time during transitions and dragging the 90lb sled.

Table 2

Sprint and jump performance for intervention and control group before and after mid-seasonal training period

	Nordic group			Control group			Between-group mean difference of changes
	Nov	Mar	Δ (%)	Nov	Mar	Δ (%)	
30 m (s)	4.10 ± 0.15	4.20 ± 0.14	+ 0.09 (+ 2.42%) ± 0.20	4.00 ± 0.09	4.16 ± 0.20	+ 0.15 (+3.88%) ± 0.15	0.04
5 m split (s)	0.90 ± 0.10	0.81 ± 0.10	- 0.08 (- 9.40%) ± 0.15	0.83 ± 0.02	0.85 ± 0.14	+ 0.02 (+3.21%) ± 0.12	0.10
10 m split (s)	1.68 ± 0.15	1.58 ± 0.13	- 0.09 (- 5.77%) ± 0.15	1.58 ± 0.04	1.63 ± 0.15	+ 0.05 (+3.17%) ± 0.11	0.14
CMJ (cm)	43.82 ± 3.67	44.97 ± 3.89	+ 1.15 (+ 2.63%) ± 4.20	44.47 ± 5.38	43.48 ± 5.85	- 0.98 (- 2.22%) ± 5.60	2.13

In addition to the high muscle activation and performance, eccentric training interventions that include Nordic hamstring curls have been shown to increase strength.<sup>26</sup> Mjolsnes et al. Conducted a 10-week training program utilizing the traditional hamstring curl and the Nordic hamstring curl and analyzed total strength increase. Strength was measured as maximal torque on a Cybex dynamometer before and after the training period.<sup>26</sup> There was an increase in eccentric hamstring extension torque and improvements to the isometric hamstring torque at 90, 60, and 30 degrees of knee flexion for the Nordic hamstring curl. The chosen interventions were 1-3 sessions per week of up to 3 x 8-12 repetition and resulted in significant strength gains in a short set/repetition intervention. Pollard et al. also similarly concluded that low volume Nordic interventions are just as advantageous as high-volume interventions at eliciting improvements to fascicle lengthening which reduce hamstring injuries.<sup>30</sup>

Week	Sessions per week	Sets and repetitions	Load (% of 1 RM)
1	1	10 RM test	
2	2	2 × 6	60%
3	3	3 × 6-8	60-80%
4	3	3 × 8-12	Progressive loading. Increase load by 2.5 kg when subject is capable of doing 3 × 12 reps
5-10	3	3 × 8-12	

RM = repetitions maximum.

Week	Sessions per week	Sets and repetitions	Load
1	1	2 × 5	Load is increased as subject can withstand the forward fall longer. When managing to withstand the whole ROM for 12 reps, increase load by adding speed to the starting phase of the motion. The partner can also increase loading further by pushing at the back of shoulders
2	2	2 × 5	
3	3	3 × 6-8	
4	3	3 × 8-10	
5-10	3	3 sets, 12-10-8 reps	

ROM: range of motion.

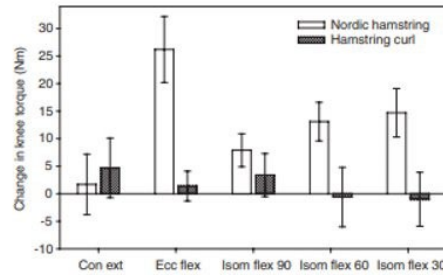


Fig. 2. Mean difference ( $\pm$  SE) in maximal torque from pre- to post-test for the Nordic hamstring ( $n = 11$ ) and hamstring curl ( $n = 10$ ) groups measured in three different strength protocols: concentric quadriceps extension torque (Con ext), eccentric hamstring flexion torque (Ecc flex) and isometric hamstring torque at 90°, 60° and 30° of knee flexion (Isom flex 90, Isom flex 60 and Isom flex 30).

Hamstring injuries are the most common muscle injuries in many sports.<sup>8</sup>

Hamstring injuries are often a result of rapid acceleration and change of direction.

Commin et al analyzed hamstring injuries specifically disruption to the central tendon

that runs between all the hamstring muscles. The median recovery time for the 62

hamstring injuries sustained was a range of 14-72 days. The results are significant

because even a minor hamstring strain can put a Soldier on profile potentially missing

crucial training needed to increase unit readiness.

The Nordic hamstring curl has been shown to reduce common injuries such as

hamstring injuries associated with sprint performance as well. A meta-analysis

conducted by Van Dyk et al. concluded that programs that include a Nordic hamstring

intervention can reduce hamstring injuries up to 51%. Sports studies represented many

of the same skills required to complete the SDC such as soccer, football, and rugby.<sup>35</sup>

There are some considerations needing to be appraised when including Nordic in

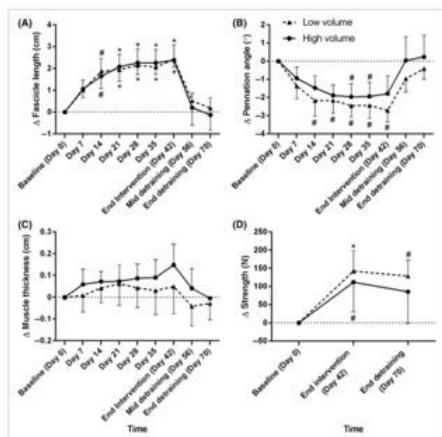
post injury training. It is not suggested as an intervention immediately following injury

because of its high activation.<sup>11</sup> In addition to no being recommended for post injury

treatment, Military members often do not have 10 weeks to commit to a strict

intervention before training exercises. Short interventions can be stunted by initial connective tissue damage done with inexperienced subjects. Six weeks appears to be the minimum amount of time to ensure full recovery and ensure that any initial connective tissue damage does not interfere with final testing results as is evident by Renoux et al's connective tissue study using ultrasounds performed within 7 days of initial injury. <sup>32</sup>

Presland et al. did conduct a 6-week protocol that included a low and high-volume intervention to codify conclusions made by those such as Pollard et al. that low volume and high volume would elicit similar improvements in overall strength. At the conclusion of the 6-week protocol there were significant improvements to fascicle length, pennation angle, muscle thickness, and overall strength. <sup>31</sup>



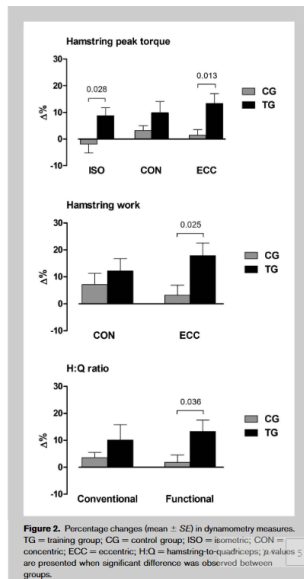
**Figure 1** Absolute change in biceps femoris long head (A) fascicle length, (B) pennation angle, (C) muscle thickness, and (D) eccentric strength across the six week training intervention and four week detraining periods. All data presented is a two-limb average of the dominant and nondominant limbs. All comparisons were within-group and compared to baseline. \*P < .001 vs baseline, \*P < .05 vs baseline. Error bars specify standard deviation from the mean

**Table 1.** Nordic hamstring exercise training intervention variables

Week	High volume intervention				Low volume intervention				
	Frequency	Sets	Reps	Total reps	Frequency	Sets	Reps	Total reps	
1	2	4	6	48	2	4	6	48	Standardized training period
2	2	4	6	48	2	4	6	48	
3	2	4	8	64	1	2	4	8	Varied volume training period
4	2	4	10	80	1	2	4	8	
5	2	5	10	100	1	2	4	8	
6	2	5	10	100	1	2	4	8	
Sum				440				128	

The application of hamstring strengthening intervention could improve performance; however, balancing the hamstring:quadriceps ratio can be important for the stability of the knee and for the balance of muscle strength.<sup>10</sup> Ribeiro-Alvarez et al did demonstrate in their 4-week Nordic hamstring intervention not only an increase in

hamstring peak torque and work, but also a significant increase in Hamstring: quadricep ratio which, when significantly different, has been shown to increase risk of hamstring injury.<sup>33</sup>



As a result of the noted desire to maintain a good quadricep: hamstring ratio, the quadriceps should not be left untrained. The Nordic hamstring curl has an opposing movement known as the reverse Nordic curl which emphasizes the hip flexors and quadricep muscles. The quadriceps are the largest group of muscles crossing the knee joint and the primary stabilizer of the knee and have the greatest potential to generate and absorb forces at the knee.<sup>10</sup> Many of the same benefits gained from the Nordic hamstring curl are attained through execution of the reverse Nordic curl. The large eccentric component lengthens the muscle tendon unit and aids in preventing injury caused by rapid lengthening and shortening of the muscle.<sup>2</sup> by combining the two variations of the movement there is potential to see improvements in force production, activation, injury resilience, peak short distance velocity, and improvements to mobility as the posterior chain, hip flexors, and quadriceps all improve muscle tendon length.

While there are many movements that could be chosen to fit many of these targeted end states, the lack of required equipment and simplicity of implementation into normal physical training benefits including the Nordic Movements to potentially improve performance and perhaps decrease risk of Musculoskeletal Injury.

## Chapter 3: Experimental Protocol:

### *Participants, Inclusion, and Exclusion Criteria, and IRB Approval*

The total length of the study will be 8 weeks. Week one will be survey, subject demographic data collection, initial testing, and group assignment. Weeks 2-7 will be the intervention weeks and will include a prescribed physical training plan for the whole subject pool and an assigned additional intervention based on group A (Nordic Complex) or Group B (Eccentric Tempo Body Weight Squat). Subjects will be recruited from the total cadet pool of the Indiana University Army ROTC program. Cadets will be informed study participation is volunteer and will not be ordered to take part in the study or reprimanded if they wish not to be part of the data collection. Subjects must be 18-25 years of age and in good health with no lower extremity surgeries or ruptures or diagnosed musculoskeletal injuries in the last 12 months. Subjects must also be able to complete the prescribed intervention without injurious pain.

### *On-boarding*

On Day 1 Subjects will be read the voluntary inclusion script if they are interested in participating in the study. If they agree they will be given the screening questionnaires (Informed Consent, Medical History and Physical Training Background). If they meet the criteria and decide to volunteer; their height will be recorded with a stadiometer (cm), weight (kg), and body fat percentage will be taken with a body total bioelectrical impedance analyzer and recorded.

On Day 2 Subjects will conduct an analysis of the subject's ability to conduct the Nordic Complex and Eccentric Tempo Body Weight Squat. Subjects will be shown an example of the movement parameters by a demonstrator. Subjects will then be instructed to

assume the starting position of tall kneeling with an upright trunk and feet in a plantarflexed position with the top of the subject's feet ideally resting on the ground. Subjects will begin the movement by lowering the subject's upper trunk backward while maintaining a straight torso. Shins will remain fixed on the ground, and subjects will lower until subjects either reach the back of the calves or the subject's maximum range of motion. Subjects will then return to the starting position. A partner will hold the subject's ankles while the subject e subject lowers the upper trunk forward resisting the urge to fall to the ground. Subjects will lower as slowly as subjects can until subjects feel the need to brace subjects fall with the subject's hands extended. Subjects will then push with a force off the ground back to the starting position to be considered once repetition of the Nordic Complex. For the Eccentric Tempo Body Weight squat, subjects will begin standing with the subject's feet just outside shoulder width. At the command begin, subjects will lower the body until the subject's leg is perpendicular to the shin and parallel to the ground. subjects will lower for the duration of three seconds or as long as they are able to if less than three seconds. Subjects will then pull themselves back up to the starting position. Disqualifying criteria for participation in the study are limited to the subject experiencing injurious or pain throughout any of the movements. The subject's RoM is not a disqualifying consideration. Disqualifying criteria for the bodyweight squat include an inability to complete 15 repetitions of the movement due to injurious pain.

### *Pre/Post Testing*

Subjects will conduct their initial testing of the Army Combat Fitness Test on Day 3. Subjects' test will be administered in accordance with the U.S Army Combat Fitness Test Field Manual. Subjects will do their best. Subjects will not be told their initial scoring time, only whether subjects maxed the scoring or failed complete the test to the

standards stated above. There will be no re-testing. If subjects are aided in any way or fail to complete one of the sections, subjects will not be allowed to participate in the study.

The first two events are the three-repetition max weight hex bar deadlift, the standing power throw, and the hand release push up maximum in two minutes. The 4<sup>th</sup> event is the sprint drag carry. References to the proper execution in the events can be found in the ACFT field manual. To start the Sprint Drag Carry event, subjects will begin in the prone position with subjects' hands behind the starting line. On the command go subjects will jump up and sprint 25 meters in subjects' lane. Touch the 25-meter line with the subjects' foot and hand, conduct a U-turn, and sprint back to the start line. Subjects will then grab each strap handle on the 90lb loaded sled. Pull the sled backward until the subjects have the sled over the 25-meter line and then turn it around and pull it back. The entire sled must cross the start line. Don't jerk the straps—use a steady pull to move the sled. Remember not to sling the sled to turn it around. Next, Face one side and perform a lateral side shuffle for 25 meters, touch the line with subjects' foot and hand, and head back to the start line. Face the same direction on the way back. Don't cross subjects feet during laterals. Then, pick up subjects pair of 40-pound kettlebells and run to the 25-meter line. Step on or over the line with one foot, turn around, and run back to the start line. Put subjects' kettlebells on the ground, turn around, and sprint to the 25-meter line. Touch the line with a hand and foot and then return to the start line as fast as subjects can. The Testing time stops once subjects cross the finish line.

Both groups will complete the prescribed physical training for that day from the attached training plan. Upon completion of training, subjects will move to the testing area to execute one of two training interventions. Subjects will either complete 3 x 15 repetitions of the Eccentric Tempo Body Weight squat or 3 x 5 repetitions of the Nordic Complex. Rest time between each set will be 2:00min. At the exercise's completion, subjects will report subjects' Perceived rate of exertion for full body and local (lower extremity) on the Borg scale of 6-20 to the investigator and then subjects will be complete. If at any time subjects feel injurious pain or are unable to complete the repetitions, subjects will note the number of completed repetitions to the investigator and then be released for the day.

The total protocol will last six weeks and consists of three training sessions a week for 18 training sessions. subjects are authorized to miss (3) total training sessions but not two in the same week. If a physical training day gets canceled by the department chair that day will be omitted from data analysis. If subjects cannot complete two training sessions, back-to-back subjects will be removed from the study.

### *Sample and Effect Size*

Previous research of the Nordic Hamstring Eccentric training in trained soccer players has demonstrated effect sizes of 0.86 and 0.80 on indicators of hamstring injury (eccentric hamstring work and Quadriceps to Hamstring strength ratio respectively). Inputting effect sizes into G Power software, the sample size was recommended to be between 34 and 42 based on the above-mentioned effect sizes. The target sample size in the study is 30 total participants randomly separated into 2 groups of 15. We have chosen 30 participants representing approximately 1/3 to 1/4 of the ROTC training group

thought we will take all volunteers into the study and report any increases in participation.

### *Data Analysis*

SPSS software will be used for analysis. We will use a T-test for our statistical analysis to compare pre- to post- ACFT scores and body composition changes. We will also use a Repeated measures ANOVA in the assessment of the average weekly Whole Body and Local Leg Rates of Perceived Exertion. A participant's data will not be included in the analysis if the participant does not complete both the pre- and post- ACFT assessment. A participant's weekly RPE data will still be assessed if they miss one training session in a single training week but will not be assessed if the participant misses 2 training sessions in the same week.

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## Chapter 4: Journal Manuscript

### *Introduction*

The modern military Soldier is required to be tactical athlete. The introduction of the Army Combat Fitness Test (ACFT) in 2019 helped mark the shift of evaluating all Soldiers physical readiness from an aerobically designed, three-event bodyweight test to a six-event test that incorporates anaerobic loaded events in addition to the aerobic events. As predicted, introducing these new dynamic movements to a population who has not been focused on strength or power as a marker of high performance in the past can lead to an increase in injury, especially musculoskeletal injury.

Musculoskeletal injuries (MSIs) have historically had a negative effect on unit readiness and if significant enough, can lead to large disability claims as a result of injuries sustained during service.<sup>18</sup> Musculoskeletal injuries are the leading cause of non-combat related injuries for military service members and are 2-3 times greater than the next leading category (mental illness).<sup>37</sup> In 2006 alone, there were over 743,500 injury-related musculoskeletal conditions.<sup>14</sup> The military injury trends has continued to an issue for the department of defense, as demonstrated in the 2019 Army Medical Surveillance report stating overuse injury continue to constitute 72% of all new non-combat related injuries. It is imperative that military leaders train their Soldiers with the same dedication to injury prevention as they do to performance so these injuries can be prevented. Proper exercise selection and programing will continue to be important to improve performance and attempt to limit unnecessary injury risk.

Army Field Manual 7-22 Holistic Health and Fitness provides training plans designed to improve performance on the ACFT as well as other domains of overall health. An area we identified that was not included was eccentrically focused movements. The concentration of the eccentric phase of movements has been shown to increase fascicle length and cross-sectional area in addition to being a potent stimulus for enhancements in the muscle tendon unit.<sup>10</sup> Often, Nordic Hamstring Exercises are chosen to eccentrically contract the hamstrings; however, proper symmetry of agonist and antagonist muscle groups is important, especially in the lower extremities such as the hamstring and quadriceps for example often referred to as the H:Q ratio.<sup>10,34</sup> We suggested adding another eccentric exercise the Reverse Nordic Curl in conjunction with the Nordic Curl to address the anterior musculature. The addition of this movement may contribute to performance, especially in sprint performance, and to decrease frequency of injury because of those events. The purpose of this study is to observe if a 6-week eccentric based training intervention can have an impact on the overall time to conduct the Sprint Drag Carry event and the subsequent events of the Army Combat Fitness test. The primary aim is to improve performance measured by a reduction in the overall time to conduct the event. The hypothesis is that those subjects that participate in the Nordic Complex group will have the greatest improvement in overall performance measured. The secondary aim of the study is injury prevention. The hypothesis is that those who participate in the Nordic Complex group will have a lower observed rate of injury during the intervention period.

## **Methods**

## ***Experimental Approach to the Problem***

An 8-week field study was developed to replicate a feasible training schedule for a military unit or Reserved Officer Training Corps (ROTC) program. These 8-weeks included an onboarding week with pre-test followed by a 6-week training plan which was developed from the recommended training days for Soldiers in Advanced Individual Training or Basic Officer Leader Course. The study finished with a final posttest to evaluate the efficacy of the training plan. Measurements taken throughout the experiment included pre and post raw scores for the 6 events of the Army Combat Fitness Test (ACFT) as well as the overall score. In addition relative perceived exertion using Borg's 6-20 scale was self-reported after each individual training session for both whole body and local (lower extremities). The limitations to a field study of this nature include a limited understanding of Perceived Exertion despite instruction. In addition, college students do not have a controlled diet, sleep pattern, or daily schedule as those Soldiers in Basic Combat Training or Advanced Individual Training. To attempt to control these variables, subjects were requested adherence to a similar daily pattern on testing days. All training sessions occurred between 0530-0700 Monday, Wednesday, and Thursday. The study (#15483) protocol was approved by the Institutional Review Board committee from Indiana University. Subjects were provided with a written informed consent before participating.

## ***Subjects***

Subjects were recruited from the Indiana Army ROTC population. The program has roughly 85 cadets ranging from Freshman (MS1) to Seniors (MS4). The ages of these cadets range from 18-25 and consist of both male and females. The pool of

applicants was given an opportunity to sign up for the study through email and then screened for participation for height (cm), body mass (kg), body fat percentage (%) and then further screened utilizing a training history questionnaire, a physical activity readiness questionnaire (PAR-Q), history questionnaire, and an injury history questionnaire. Disqualifying criteria included any positive responses to the PARQ or any lower extremity injury that resulted in surgical intervention. Out of the 27 applicants that were interested all 27 were admitted to the study (Table 1).

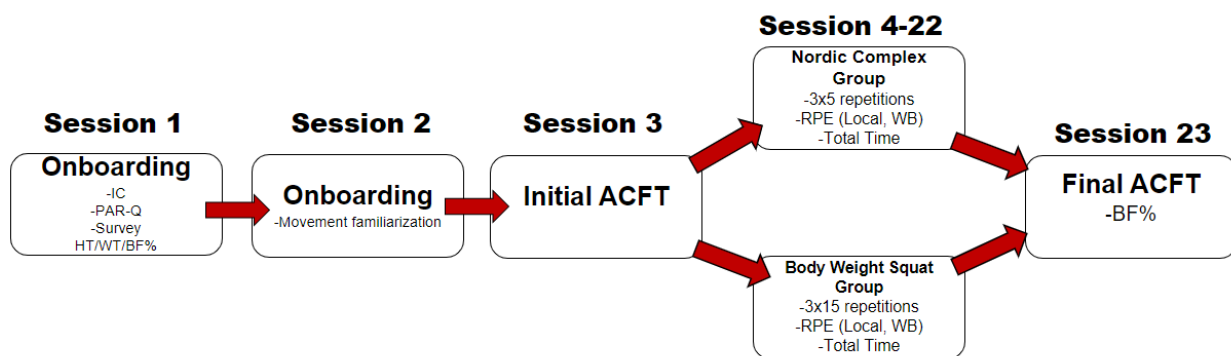
**Table 1. Participant demographics separate by groups**

	Nordic Males (n=9)	Nordic Female (n=2)	Squat Male (n=8)	Squat Female (n=3)
Age (yrs)	20 ± 1.59	20 ± .7	19 ± 1.3	19 ± 2.1
Height (m)	1.77 ± .08	1.64 ± .06	1.80 ± .09	1.69 ± .1
Weight (kg)	81.39 ± 10.8	58.35 ± 3.8	78.31 ± 13.6	63.5 ± 10.2
Body Fat % (pre)	17.58 ± 3.2	22 ± .28	13.62 ± 4.5	24.63 ± 2.1
Body Fat % (post)	18.2 ± 3.0	21.7 ± .7	13.6 ± 4.7	22.7 ± .83

## Procedures

Utilizing a repeated measures design, subjects underwent an 8-week field study that consisted of an onboarding/pre-testing week, 6-weeks of training, and a post-test week (Figure 1). During week 1, subjects were screened utilizing the PAR-Q, injury questionnaire, and training history. Body fat percentages were taken using Bioelectrical Impedance Analysis (BIA). Height was measured using a stadiometer. Subjects were given a demonstration of both intervention movements, the eccentrically focused body weight squat and the Nordic Complex. Subjects were screened to ensure they did not experience injurious pain during execution. Range of motion was neither recorded nor

of concern. Once complete with screening, the entire IU Army ROTC conducted an ACFT in accordance with ATP 7-22 Holistic Health & Fitness ACFT test administering guidelines. Scores were recorded in accordance with ATP 7-22 and the ACFT Field Manual and those enrolled in the study were separated by a randomized generator into one of two groups (N=11). There was a one-week washout period before subjects began the 6-week training intervention.



**Figure 1. Study Design**

For 6-weeks, all the Indiana University Army ROTC cadets (including those not involved in the study) conducted physical training Monday, Wednesday, and Thursday from 0600-0700. Training was conducted outside at the track and field stadium or at the indoor track and field facility. Both locations provided a turf surface and oval track (outside 400m, indoor 200m). Their physical training plan was developed from the Army's Regulation governing physical training, Field Manual (FM) 7-22 Holistic Health and Fitness. Excerpts from the Basic Officer Leader Course and Advanced Individual Training schedules were implemented based on the experience level of the cadets. All

training was done in traditional military physical training formations in the standard Army Physical Fitness Uniform consisting of a T-shirt, Long sleeve shirt, Athletic Shorts, Jacket, pants and tennis shoes. The uniform was altered based on ambient temperature and wind chill. Indoor uniform was always t-shirt, shorts, and tennis shoes. In total 15/18 sessions were conducted (three were cancelled due to weather).

Upon completion of the daily training plan (Figure 2), subjects enrolled in the study would immediately perform one of the two interventions. Subjects in the eccentric squat group conducted 3 sets of 15 repetitions with a 3 second eccentric phase. Subjects in the Nordic Complex conducted 3 sets of 5 repetitions utilizing a partner for the forward movement. The squat movement was selected because it is a familiar movement that is already involved in military training. The aim in using the body weight squat versus a tempo body weight squat was to match the workload of the Nordic Complex group. The repetition scheme for the squat group was developed based on pre-screened time to completion average of the Nordic Complex group. Subjects RPE was recorded immediately following completion of the sets on a Borg scale (6-20). RPE was recorded for both whole body and local (lower extremity). Time to completion of repetitions was also recorded. The repetitions and expected time to completion were based on reducing the additional time required for cadets to remain at training once the daily training plan was complete.

**Figure 2. Sample Training Week** (Week 2) *FM 7-22 Holistic Health and Fitness*

		Primary Conditioning Drills				
<b>Monday</b>	PD	SSD	CD 1 (10 reps)	SDCR		RD

<b>Wednesday</b>	PD	HSD	4 for the Core	2 x 1min plank	CD 2 (10 reps)	RD
<b>Thursday</b>	PD	MMD	300yd Shuttle Run x 2			RD

**PD-** Preparation Drill

**SSD-** Shoulder Stability Drill

**HSD-** Hip Stability Drill

**SDC-** Sprint Drag Carry Repetition

**RD-** Recovery Drill

**CD-** Conditioning Drill

**MMD-** Military Movement Drill

**GTA 07-08-003 Physical Readiness Training Quick Reference Card**

**ATP/ FM 7-22 Holistic Health and Fitness**

## Statistical Analysis

Overall Score change for each event and overall was inputted ] SPSS software was used for statistical analyses (IBM, Chicago, IL). Multiple individual split-plot ANOVAs were used to compare pre- to post- ACFT event results (sum of individual 6 event score; each worth 100pts.), ACFT overall score, and body composition changes. Homogeneity of variance was checked using Leven's test of equality of error variances. No violation of sphericity was observed using Mauly's test of Sphericity. Multiple T-Tests were used to assess average weekly Whole Body and Local Leg Rates of Perceived Exertion. This was done due to violations in sphericity observed when running ANOVA. A participant's data was not included in the analysis if the participant did not complete both the pre- and post- ACFT assessment. N= 22, alpha level set to  $p \leq .05$

## Results

No significant main effect was observed within groups when comparing the two interventions. (Table 2) A significant main effect of score change was observed indicating both groups improved the overall ACFT Score ( $p < .001$ ). Specifically, main effects of time for sprint drag carry ( $p < .001$ ), deadlift ( $p = .001$ ), the 2-mile run ( $p = 0.045$ ), and overall score ( $p < .001$ ) (Table 3).

However, the relatively consistent RPE reporting might suggest the cadets were adequately adjusting their intensity to stay in the same state each session. Body composition (bw%) did not significantly differ from pre to posttest analysis.

**Table 2. Intervention ACFT Event Scores and Overall Score Changes**

	Nordic (pre)	Nordic (post)	% Change ( $\pm$ )	Squat (pre)	Squat (post)	% Change ( $\pm$ )
HBDL (lbs)	255.4 $\pm$ 80.0	266.3 $\pm$ 75.0	4.27%	231.8 $\pm$ 69.9	253.6 $\pm$ 71.4	9.41%
SPT (m)	8.80 $\pm$ 2.2	8.90 $\pm$ 2.2	1.1%	8.50 $\pm$ 2.28	8.46 $\pm$ 2.18	-1.00%
HRP (reps)	40.3 $\pm$ 11.3	37.4 $\pm$ 12.9	-7.7%	37.5 $\pm$ 10.1	37.8 $\pm$ 10.2	0.7%
SDC (sec)	116.0 $\pm$ 15.7	104.4 $\pm$ 14.3	11.1%	112.9 $\pm$ 22.8	103.0 $\pm$ 15.3	9.6%
Plank (sec)	138.45 $\pm$ 45	149 $\pm$ 44.6	7.6%	166.7 $\pm$ 54.3	180.6 $\pm$ 48.8	8.3%
2-Mile Run (sec)	979.0 $\pm$ 82.3	972.4 $\pm$ 79.3	-0.6%	966.9 $\pm$ 143.5	920.9 $\pm$ 114.7	4.9%
Overall Score (max 600)	496.2 $\pm$ 46.2	510.2 $\pm$ 45.5	2.8%	512.1 $\pm$ 46.1	529.8 $\pm$ 34.5	3.4%

**Table 3. Combined ACFT Event Scores and Overall Score Changes**

	Combined (pre) (n=22)	Combined (post) (n=22)	% Change ( $\pm$ )
HBDL (lbs)	243.6 $\pm$ 74.3	260.0 $\pm$ 71.7*	6.7%

SPT (m)	8.65 ± 2.2	8.68 ± 2.1	.3%
HRP (reps)	38.9 ± 10.6	37.6 ± 11.4	-3.4%
SDC (sec)	114.5 ± 19.2	103.7 ± 14.5*	10.4%
Plank (sec)	152.5±50.8	164.8±48.4	8%
2-Mile Run (sec)	973.0±114.3	946.6±98.8*	2.7%
Overall Score (max 600)	504.1±45.8	520.0 ±40.7*	3.1%

\*Significant main effect observed CI set to .05

## Discussion

The purpose of this study was to determine whether adding eccentric focused exercises to a training program based on the prescribed physical readiness plans by Field Manual and Army Techniques Publication (ATP) 7-22 Holistic Health and Fitness, would increase performance in the ACFT. There was a lack of significance observed between the two intervention groups, indicating both interventions had efficacy in improving individual event performance as well as overall performance. Cadets across both intervention groups demonstrated a mean improvement following the 6-weeks of training.

Our findings are in agreement with results from a training study involving the ROTC at Colorado State.<sup>25</sup> That 10-week training period comparing traditional training plans like the one developed here and compared it against High Intensity Interval Training (HIIT).<sup>25</sup> Their cadets reported an improvement of 6.2% in overall score on the Army Physical Fitness Test of old with no interaction between groups.<sup>25</sup> We reported a mean improvement of 3.1% (n=22) with no interactions. The improvement observed could be attributed to any number of factors; one likely factor is a well-designed

supervised training plan from Field Manual 7-22 Holistic Health and Fitness aimed at improving performance in the test. The lack of observed improvement, however, could be attributed to some of the limitations of the study.

Possible reasons for the lack of difference in performance for the intervention group versus the unenrolled members of the battalion could be multifaceted. The repetition and sets for the eccentric exercises were designed to allow cadets to complete the intervention in a timely manner following a normal training session to not interfere with their class schedules. The training load could have been too low to elicit more of an improvement than was already occurring from the normal training plan. The training load was developed in response to previous research that was able to find similar improvements in fascicle length and strength for both low and high-volume Nordic Hamstring Exercise (NHE) completed over a similar 6-week training period.<sup>32</sup> Krommes et al., (2017) observed increases to the first 5m and 10m split of 30m sprints in soccer players after a 10-week mid-season training intervention that included a focus on Nordic hamstrings.<sup>19</sup> Mjøl̄snes (2004) also saw significant effects on hamstring-to-quadriceps ratio and maximum torque after 10-weeks of eccentric hamstring training in soccer players.<sup>27</sup> While there was reported transfer between eccentric training and sprint performance it is only one aspect of the sprint, drag, carry. Adding additional movements such as loaded carries may have added to the performance benefit.

Our study design included RPE as a mechanism to assess self-reported training intensity as a means of determining if the cadets were maintaining proper progressive overload for the duration of the intervention. The RPE scale was explained to the cadets during the informed consent and again after each session. A scoring reference

sheet was provided in an attempt to ensure the cadet's self-reported scores were provided to the best of their understanding. It is difficult to determine if the low deviation in reported scoring was a result of the cadets adjusting intensity between sessions or if they were limited by an incomplete understanding of RPE. A future study may benefit from adjusting the repetition scheme at the midway point based on the reported Relative Perceived Exertion (RPE). The daily data reflected a relatively constant RPE that only mildly fluctuated throughout the week.

This study was designed to address training for performance and readiness but also to implement an eccentric exercise modality in the training program that has shown to attenuate injury<sup>17,20,28,34,36</sup>. There were no injuries reported in either the Nordic or Squat intervention groups during the 6-weeks of training in this study. The lack of injury in the intervention groups may not be attributed to eccentric training as there was only one injury sustained during the training period in the whole participant and non-participant population. The single injury was unrelated to the training program as it occurred moving from station to station. The intentional supervised implementation of the training program accompanied by athletic trainer oversight and appropriate training load likely combined to result in no training time lost from injury. It is also of note that none of the cadets involved in the intervention study sustained an injury even with the increase in training load and relatively unfamiliar movement pattern. The lack of injury may be more impactful when compared to a risk factor analysis study conducted by Scott et al. 2015 recorded data from 2012-2013 with 195 cadets over two school years that yielded an injury rate of about 60% during a school year.<sup>35</sup> The ROTC group in that study had a high prevalence of musculoskeletal injury rates in the knee and

predominately in the MS1 i.e. freshman class. It is of note that 5 of the 22 participants in the present? study were from the freshman class. A direct comparison between the current study and the study by Scott et al. is limited as the programs were not provided for the 2012-2013 and, at the time of Scott's work, the previous iteration Army Physical Fitness Test was still the test of record and recommended training plans consisted of extensive aerobically focused steady state training. Even with the introduction of more complex movements and loaded movements of the Army Combat Fitness Test, there was not only a reduction in that observed injury risk but almost a complete abolishment in injuries observed or reported for the semester.<sup>36</sup> The low rate of injury incidence does support a meta-analysis conducted by Van dyk et al. (2019) that reported programs that included a Nordic Hamstring Exercise resulted in up to 51% reduction in hamstring injuries. It is noteworthy to include the dedicated Athletic Trainer that is present at all training sessions and holds available evaluation appointments in a very similar manner as a collegiate athlete and is not available at in every ROTC program and provides

### **Practical Application**

The designed training plan developed from the Army manual, aside from the intervention, appeared to be effective in improving cadets' overall ACFT score. The training plan was taken from FM 7-22 Holistic Health and Fitness and appears to have demonstrated strong ecological validity when applied correctly. The low observed injury rate could be a result of the relatively low training load in comparison to what the cadets have done in previous semesters. This was done to limit the additional time cadets had to commit to following the normal training sessions. Keeping specificity and intensity high but maintaining a lower training load can reduce overall training time and could

have an impact on overuse injuries.<sup>14, 37</sup> Having more involvement by coaches or leaders at the unit level to control the attitude and approach of the training plan in its implementation could impact the efficacy of the overall training plan. During these 6-weeks the physical training plan was given to the cadets which forced them to learn the mobility drills, cadence tempo, and how to identify incorrect form and intensity to assist their peers. Spending the time to work on these skills at the lowest level may have transfer into performance results and injury mitigation.

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# **Appendix A: Informed Consent**

## **INDIANA UNIVERSITY INFORMED CONSENT STATEMENT FOR RESERACH**

### **Effect of Eccentric Training Intervention on Performance During the Spring, Drag, Carry Event of the Army Combat Fitness Test**

**IRB #15483**

You are being asked to participate in a research study. Scientists do research to answer important questions which might help change or improve the way we do things in the future.

This Consent form will provide will give you information about this study to help you decide whether you want to participate. It is your choice whether or not you want to be in this research study. Please read this form, and ask any questions you have, before agreeing to be in this study.

#### **WHY IS THIS STUDY BEING DONE?**

This study is being done to determine if certain types of movement, particularly in the lower extremities, could have a positive impact on an individual's score when completing the Army Combat Fitness Test. (ACFT). In addition, the results of this study could provide military commanders and fitness coordinators with additional tools to train their formations and potentially reduce injuries across the military.

We are asking if you want to be in this study because you expressed interest in the study and have completed questionnaires that indicate you have no current or past medical conditions or injuries that would prevent you from participating.

The study is being conducted by Jacob Davel and Dr. Brian Moscicki, Kinesiology Department at Indiana University-Bloomington

#### **WHAT WILL HAPPEN DURING THE STUDY?**

All study procedures will take place at Hayes Track (Indiana University track and field facility) or Gladstein Fieldhouse (indoor track and field facility) weather dependent.

If you agree to participate you will do the following:

### **Study visit 1/week 1**

- Your height and weight will be measured. Your body composition will also be assessed using a Bioelectrical Impedance Analyzer (BIA). The BIA measures the rate at which low, painless electrical currents travel throughout your body. This measurement can give us an estimate of your total fat-free mass. To complete the assessment, you will be asked to remove your socks and shoes. You will stand on a special scale and will hold an electrode in each hand. The electrodes look like small handles. Two readings will be taken and then averaged for measures of body weight (kg or lbs.), body fat percentage (%), and total body water (%). You will be provided with a standard set of hospital scrubs to wear for body weight and composition measurements. The duration of this test is anticipated to take approximately 10 seconds per reading.
- Next you will be asked to complete a questionnaire regarding your sports and exercise training history.
- You will be shown an example of how to complete both the Nordic Complex and the Eccentric Tempo Body Weight Squat by a demonstrator. The researchers will then determine your ability to conduct the Nordic Complex and the Eccentric Tempo Body Weight Squat by having you complete these exercises as well.
- o To start the assessment of the Nordic Complex, you will be instructed to assume the starting position of “tall kneeling” which is when your trunk is upright with your toes pointed, and with the top of your foot ideally resting on the ground. You will begin the movement by lowering your upper trunk backward while maintaining a straight torso. Shins will remain fixed on the ground, and you will lower until you either reach the back of your calves or the lowest you can move your trunk back without causing injurious pain. You will then return to the starting position. A partner will hold your ankles while you lower your body forward resisting the urge to fall to the ground. You will lower as slowly as you can until you feel the need to brace your fall with your hands extended. You will then push with a force off the ground back to the starting position. This is considered one repetition of the Nordic Complex.
- o For the Eccentric Tempo Body Weight Squat, you will begin standing with your feet just outside shoulder width. At the command “begin,” you will lower your body until your upper leg is parallel to the ground. The lowering portion of the squat should be completed in three seconds. Once you reach the bottom of the

squat, you will then stand back up to the starting position at your own pace. This is considered one repetition of the Eccentric Tempo Body Weight Squat.

- You will be asked to do 3 sets of 5 repetitions of the Nordic Complex and 3 sets of 15 repetitions of the Eccentric Tempo Body Weight Squat. If you indicate when asked that you are experiencing any pain, you will be removed from the study to prevent any further pain or possible injury.

This visit will take approximately 30-40 minutes to complete.

**Study visit 2/week 1: (scheduling of visit is based upon the time required to take the test, supplies needed, and staff availability)**

- You will complete the Army Combat Fitness Test (ACFT). The test will be administered in accordance with the U.S Army Combat Fitness Test Field Manual test script. The ACFT consists of 6 different exercises. You will be asked to do your best in all events:
  1. 3 repetition maximal deadlift- this exercise uses a hexagon deadlift bar with a ten-minute warm-up. You will perform three-repetition maximum deadlift. Maximum refers to the most amount of weight you can safely conduct three repetitions with. The maximum weight allotted to reach 100 points in the event is 344 pounds.
  2. A standing power throw- this exercise utilizes a ten-pound medicine ball which you will throw over your torso backwards for a maximum distance.
  3. Hand-release push-up- this exercise involves you releasing your hands out to a "T" once your body touches the ground and is otherwise a normal push-up.
  4. Sprint-drag-carry- this involves 10, 25-meter shuttle sprints. Two 25-meter sprint shuttles, two 25-meter shuttles dragging a sled with 90lbs of weight on top, two 25-meter shuttles of lateral shuffle, two 25-meter sprints hand-carrying two 40lb kettlebells, and finally two 25-meter sprints to finish. This event will be timed.
  5. The maximum effort plank, which involves remaining in an extended position on toes and elbows for the maximum amount of time possible.
  6. Finally, you will be asked to complete a 2-mile run. This event will be timed as well.
    - o You will be shown how to do each exercise and will also be allowed to demonstrate the exercise to ensure you are completing it safely and correctly. You will also be given a print-out that contains detailed information regarding each exercise.
- You will be allotted 10 minutes to warm-up before beginning the test and are expected to complete the test within 70 minutes but can exceed that time if needed. You will also have 2- 5 minutes between each exercise to rest, depending upon the exercise.

- During the ACFT, you will be wearing a device called an “accelerometer” that will measure your movement. This device will be attached around your waist using a retaining band and will be located on the center of your lower back at your waistline.

This study visit will take approximately 90 minutes to complete.

### **Study visits 3-20/weeks 2-7**

You will be randomized (like flipping a coin) into either the “Nordic Complex” group or the “Eccentric Tempo Body Weight Squat” group.

- You will complete an ROTC training plan as part of your normal ROTC duties that involves 3 sessions a week, for 6 weeks. The exercises have been developed by the Army and are not a study procedure, meaning you would complete these exercises regardless of if you chose to participate in the study.
  - o As a participant in this study, you will be asked to complete additional exercises at the end of each training session. Depending upon the group you have been randomized to, you will either complete 3 sets of 5 repetitions of the Nordic Complex, or 3 sets of 15 repetitions of the Eccentric Tempo Body Weight Squat, the same exercises you completed during week 1. You will be given two minutes to rest between each set.
  - o At the completion of each set, you will be asked to rate how difficult it was to complete each set of exercises on a scale of 6-20, 6 being the easiest and 20 being maximal effort. A print-out of the scale will be available for you to reference. If at any time you feel injurious pain or are unable to complete the exercises, you will tell the study team member the number of repetitions you completed and this will complete your data collection for the day. You will then be evaluated by the IU Training Staff who will determine if you are medically eligible to continue with data collection at the next scheduled date. If it's recommended that you receive further treatment that could result in missing more than the allotted data collections, you may be removed from the study.
  - o You are authorized to miss (3) total training sessions but not two in the same week. If you are unable to complete two training sessions back-to-back you will be removed from the study and continue your regular training plan as part of your ROTC required duties.

Each training session will last one hour with the additional exercises taking approximately 5-10 minutes to complete.

### **Study visit 21/week 8**

- We will once again measure your body composition using a Bioelectrical Impedance Analyzer (BIA) just as was done during the first week.
- Next, you will complete the ACFT again. You will be given time to warm-up and time between each of the 6 exercises to rest, just as was done during the first week.
- You will once again wear the accelerometer which will measure your movement.

This visit will take approximately 95 minutes to complete.

**Regardless of the group you are randomized to, you will be in the study for about 8 weeks.**

You will not be told your score when you complete the ACFT the first week but will be told your score when you complete the ACFT the second time during week 8. You will be given the results of your body composition analysis (including a comparison of before and after the 6-week training period) at the end of the study. This body composition analysis will be emailed to you upon completion of the study.

### **WHAT ARE THE RISKS OF TAKING PART IN THE STUDY?**

Participation in this study is not expected to increase your risk of injury to any greater extent than your normal training and testing with the ROTC. You will complete the same training as non-study participants, with the addition of completing exercises at the end of each day of training and completing the ACFT twice more than the current Army requirement of completing the ACFT twice a year.

The risks associated with the study are the same as other prolonged exercise training programs. These potential risks are musculoskeletal injuries and muscle soreness or fatigue. To minimize these risks, you will be given time to rest between all exercises and will be asked if you are experiencing any pain. If you are experiencing pain, you will be evaluated by the Indiana University Athletic Training Staff (who will be on site daily),

who will determine if you are medically eligible to continue with data collected at the next scheduled date. If you are recommended for further treatment that could result in missing more than the allotted data collections, you may be withdrawn from the study. Water will also be available to ensure you receive proper hydration during exercise. All exercises will be demonstrated before being asked to complete them, to ensure you are completing them as safely as possible.

There is a risk someone outside the study team could gain access to your research information from this study. More information about how we will protect your information to reduce this risk is below.

There are no risks associated with measuring your height and weight or body composition.

## **WHAT ARE THE BENEFITS OF TAKING PART IN THE STUDY?**

We don't know that you will benefit from taking part in this study, but participation may result in an improvement in your ACFT score and overall improvement in your personal fitness.

## **HOW WILL MY INFORMATION BE USED?**

The following individuals and organizations may receive or use your identifiable information:

- The researchers and research staff conducting the study
- The Institutional Review Boards (IRB) or its designees that review this study
- Indiana University
- US government or agencies as required by law

Information for this research may be used for future research studies or shared with other researchers for future research. If this happens, information which could identify you will be removed before any information is shared. Since identifying information will be removed, we will not ask for your additional consent.

## **HOW WILL MY INFORMATION BE PROTECTED?**

Every effort will be made to keep your personal information confidential, but we cannot guarantee absolute confidentiality. No information which could identify you will be shared in publications about this study. Your personal information may be shared outside the research study if required by law and/or to individuals or organizations that oversee the conduct of research studies. Data will be recorded with numerical identifiers. Numerical identifiers and hardcopy forms will be stored securely in Dr. Moscicki's office in the School of Public Health at the IU campus.

## **WILL IT COST ME ANYTHING TO PARTICIPATE?**

There are no costs associated with participation in this study.

## **WILL I BE PAID FOR PARTICIPATION?**

There is no payment or financial compensation associated with this study.

## **COMPENSATION FOR INJURY**

In the event of physical injury resulting from your participation in this research when you are at physical training you will be assessed by the athletic training department staff and then recommended for any follow up appointments. Any medical treatment and costs not covered by your health care insurer will be your responsibility. Also, it is your responsibility to determine the extent of your health care coverage. There is no program in place for other monetary compensation for such injuries. However, you are not giving up any legal rights or benefits to which you are otherwise entitled including any available through the ROTC program. If you are participating in research which is not conducted at a medical facility, you will be responsible for seeking medical care and for the expenses associated with any care received.

## **WHO SHOULD I CALL WITH QUESTIONS OR PROBLEMS?**

For questions about the study or a research-related injury, contact the researcher Jacob Davel at (262) 227-7928 or [jjdavel@iu.edu](mailto:jjdavel@iu.edu) .

In the event of a medical emergency, call 911.

For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the IU Human Subjects Office at (800) 696-2949 or [irb@iu.edu](mailto:irb@iu.edu).

### **WHAT IF I DO NOT PARTICIPATE OR CHANGE MY MIND?**

After reviewing this form and having your questions answered, you may decide to sign this form and participate in the study. Or, you may choose not to participate in the study. This decision is up to you. If you choose not to participate in this study or change your mind after signing this document, it will not affect your usual medical care or treatment or relationship with Indiana University.

If you change your mind and decide to leave the study in the future, the study team will help you withdraw from the study safely. If you decide to withdraw, please notify the research team as soon as you have made the decision to withdraw, once confirmed, all collected data will be destroyed and your subject number will be removed from the study.

The researchers may stop your participation in the study even if you do not want to stop if the athletic training staff determines it is unsafe for you to continue, or you miss more than three total training sessions or two sessions in one week. You will be notified in person and by email of your withdrawal from the study which will occur prior to the next study visit, and all data collection and records will be destroyed.

### **PARTICIPANT'S CONSENT**

In consideration of all of the above, I agree to participate in this research study.

I will be emailed a copy of this informed consent document to keep for my records (paper copies available upon request, if preferred over email).

**Subject's Printed Name:** \_\_\_\_\_

**Subject's Signature:** \_\_\_\_\_

Date: \_\_\_\_\_

(must be dated by the subject)

**Printed Name of Person Obtaining Consent:**

\_\_\_\_\_

**Signature of Person Obtaining Consent:** \_\_\_\_\_ **Date:**

\_\_\_\_\_

**Participant Contact Information** (utilized for communication and sending final body composition analysis)

Email Address:

## **Appendix B: Investigator Script**

### **Eccentric Research Study**

*IRB # 15483*

#### **VERBAL SCRIPT**

Hello **[potential participant name here]**,

My name is **[enter study personnel name here]** from the Kinesiology department at IU Bloomington. Thank you for your interest in participating in our research study. The purpose of this study is to determine if certain types of movement, particularly in the lower extremities, could have a positive impact on an individual's score when completing the Army Combat Fitness Test. (ACFT). In addition, the results of this study could provide military commanders and fitness coordinators with additional tools to train their formations and potentially reduce injuries across the military. If you are interested in helping us determine this information, you will be asked to stay after normal Physical Training to fill out questionnaires about your health history and injury history.

**[verbal only]** Do you agree to participate in this screening process?

***If no:*** Unfortunately, you will not be able to participate without us determining your eligibility. Thank you very much for your interest in the study. Please return to your cadre to resume normal physical training.

The screening questionnaires will be used solely for the purpose of determining your eligibility for this study. None of the information you provide for this screening, or any information contained in our email exchanges will be shared with anyone outside the study personnel. If you agree to participate in this screening, you will be asked Yes-or-No and open-ended questions about your health history and previous injuries. Your participation in this screening is entirely voluntary; there will be no cost or payment for participating in this screening. You may choose not to answer questions if you wish, and you may stop the screening at any time. Following the responses to the screening questions, if you do not qualify for this study, your name, information, and all email strings between you and I will be permanently destroyed.

If you do qualify for the study, the answers to the screening questions, your name, and your contact information will be stored in password protected electronic files stored on a secure server for which only the study personnel will have access. Any paper documents will be stored in a secure file cabinet in a locked office in the IU School of Public Health building for which only the study personnel will have access.

You are expected to answer all questionnaires honestly to not only ensure your safety, but to provide the most accurate data collection. You are also expected to respect to all other participants and research staff. Honest feedback throughout the process is needed to ensure the protocol is being adhered to and no adverse effects occur. Finally, ask questions if something intrigues you, or you are curious about any element of the project.

**Screening Questionnaires:**

*Screening questionnaires and writing utensils will be provided by researchers to those who wish to participate.*

**PAR-Q plus 2020 – Physical Activity Readiness Questionnaire**

**Screening/Knee Injury History Questionnaire**

**Participants will be emailed with eligibility results**

**Response if the participant qualifies:**

Hello **[potential participant name here]**,

Thank you for answering the screening questions. Based on the answers to the screening questions, you qualify for the study.

Are you interested in participating in the study? If so, the next step is to meet with study personnel to review the informed consent document. We will gather some basic demographic information (age, gender, height, weight, etc.,) and then you will be scheduled for your initial assessment and Army Combat Fitness Test (ACFT) assessment.

As a reminder, all information exchanged between us via email will not be shared with anyone outside the study personnel and all email strings will be destroyed after your participation is complete. You have the right to withdraw your consent and discontinue your participation at any time without penalty.

Do you have any questions about participating in the study or about the study itself? Feel free to contact me at any time if you have questions.

Thank you very much for your interest in the study. I look forward to hearing from you.

***[Enter study personnel name]***

***[Study personnel phone number]***

***[Study personnel email address]***

**Response if the participant does not qualify:**

Verbal Response

Thank you for your interest in participating; unfortunately, you do not qualify for this study. You will move back with the rest of the formation and continue with training for today. Your questionnaires and all other documentation relating to this study will be destroyed immediately following today's screening session.

Email Response

Hello **[potential participant name here]**,

Thank you for responding to my email and answering the screening questions. Unfortunately, you do not qualify to participate at this time, but we greatly appreciate your time and interest in the study. Please feel free to contact us if you have remaining questions about the study or our lab.

All of our email strings will be destroyed. We will keep the answers to your screening questions to help identify for which reasons why interested individuals were excluded from the study. I

Thank you very much for your interest in our study.

***[Enter study personnel name]***

***[Study personnel phone number]***

***[Study personnel email address]***





## Appendix C: 2020 PAR-Q+


# 2020 PAR-Q+






### The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

#### GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition <input type="checkbox"/> OR high blood pressure <input type="checkbox"/> ?	<input type="checkbox"/>	<input type="checkbox"/>
2) Do you feel pain in your chest at rest, during your daily activities of living, OR when you do physical activity?	<input type="checkbox"/>	<input type="checkbox"/>
3) Do you lose balance because of dizziness OR have you lost consciousness in the last 12 months? Please answer NO if your dizziness was associated with over-breathing (including during vigorous exercise).	<input type="checkbox"/>	<input type="checkbox"/>
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? PLEASE LIST CONDITION(S) HERE: _____	<input type="checkbox"/>	<input type="checkbox"/>
5) Are you currently taking prescribed medications for a chronic medical condition? PLEASE LIST CONDITION(S) AND MEDICATIONS HERE: _____	<input type="checkbox"/>	<input type="checkbox"/>
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer NO if you had a problem in the past, but it does not limit your current ability to be physically active. PLEASE LIST CONDITION(S) HERE: _____	<input type="checkbox"/>	<input type="checkbox"/>
7) Has your doctor ever said that you should only do medically supervised physical activity?	<input type="checkbox"/>	<input type="checkbox"/>

 **If you answered NO to all of the questions above, you are cleared for physical activity. Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.**

-  Start becoming much more physically active – start slowly and build up gradually.
-  Follow Global Physical Activity Guidelines for your age (<https://apps.who.int/iris/handle/10665/44399>).
-  You may take part in a health and fitness appraisal.
-  If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
-  If you have any further questions, contact a qualified exercise professional.

#### PARTICIPANT DECLARATION

If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for its records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.




NAME \_\_\_\_\_ DATE \_\_\_\_\_

SIGNATURE \_\_\_\_\_ WITNESS \_\_\_\_\_

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER \_\_\_\_\_

 **If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.**

#### Delay becoming more active if:

-  You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
-  You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at [www.epafmedx.com](http://www.epafmedx.com) before becoming more physically active.
-  Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

# 2020 PAR-Q+

## FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

- 1. Do you have Arthritis, Osteoporosis, or Back Problems?**  
If the above condition(s) is/are present, answer questions 1a-1c      If **NO**  go to question 2
- 1a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)      YES  NO
- 1b. Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)?      YES  NO
- 1c. Have you had steroid injections or taken steroid tablets regularly for more than 3 months?      YES  NO
- 
- 2. Do you currently have Cancer of any kind?**  
If the above condition(s) is/are present, answer questions 2a-2b      If **NO**  go to question 3
- 2a. Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and/or neck?      YES  NO
- 2b. Are you currently receiving cancer therapy (such as chemotherapy or radiotherapy)?      YES  NO
- 
- 3. Do you have a Heart or Cardiovascular Condition? This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm**  
If the above condition(s) is/are present, answer questions 3a-3d      If **NO**  go to question 4
- 3a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)      YES  NO
- 3b. Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction)      YES  NO
- 3c. Do you have chronic heart failure?      YES  NO
- 3d. Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months?      YES  NO
- 
- 4. Do you currently have High Blood Pressure?**  
If the above condition(s) is/are present, answer questions 4a-4b      If **NO**  go to question 5
- 4a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)      YES  NO
- 4b. Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer **YES** if you do not know your resting blood pressure)      YES  NO
- 
- 5. Do you have any Metabolic Conditions? This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes**  
If the above condition(s) is/are present, answer questions 5a-5e      If **NO**  go to question 6
- 5a. Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-prescribed therapies?      YES  NO
- 5b. Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness.      YES  NO
- 5c. Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, **OR** the sensation in your toes and feet?      YES  NO
- 5d. Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)?      YES  NO
- 5e. Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future?      YES  NO

# 2020 PAR-Q+

**6. Do you have any Mental Health Problems or Learning Difficulties?** This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome  
If the above condition(s) is/are present, answer questions 6a-6b If **NO**  go to question 7

6a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES  NO

6b. Do you have Down Syndrome **AND** back problems affecting nerves or muscles? YES  NO

**7. Do you have a Respiratory Disease?** This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure  
If the above condition(s) is/are present, answer questions 7a-7d If **NO**  go to question 8

7a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES  NO

7b. Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy? YES  NO

7c. If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week? YES  NO

7d. Has your doctor ever said you have high blood pressure in the blood vessels of your lungs? YES  NO

**8. Do you have a Spinal Cord Injury?** This includes Tetraplegia and Paraplegia  
If the above condition(s) is/are present, answer questions 8a-8c If **NO**  go to question 9

8a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES  NO

8b. Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting? YES  NO

8c. Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)? YES  NO

**9. Have you had a Stroke?** This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event  
If the above condition(s) is/are present, answer questions 9a-9c If **NO**  go to question 10

9a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES  NO

9b. Do you have any impairment in walking or mobility? YES  NO

9c. Have you experienced a stroke or impairment in nerves or muscles in the past 6 months? YES  NO

**10. Do you have any other medical condition not listed above or do you have two or more medical conditions?**

If you have other medical conditions, answer questions 10a-10c If **NO**  read the Page 4 recommendations

10a. Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months **OR** have you had a diagnosed concussion within the last 12 months? YES  NO

10b. Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)? YES  NO





10c. Do you currently live with two or more medical conditions? YES  NO

**PLEASE LIST YOUR MEDICAL CONDITION(S)  
AND ANY RELATED MEDICATIONS HERE:** \_\_\_\_\_  
\_\_\_\_\_

**GO to Page 4 for recommendations about your current  
medical condition(s) and sign the PARTICIPANT DECLARATION.**




# 2020 PAR-Q+

 **If you answered NO to all of the FOLLOW-UP questions (pgs. 2-3) about your medical condition, you are ready to become more physically active - sign the PARTICIPANT DECLARATION below:**

-  It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs.
-  You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.
-  As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.
-  If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

 **If you answered YES to one or more of the follow-up questions about your medical condition:** You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the ePARmed-X+ at [www.eparmedx.com](http://www.eparmedx.com) and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.

 **Delay becoming more active if:**

-  You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
-  You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at [www.eparmedx.com](http://www.eparmedx.com) before becoming more physically active.
-  Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

- You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.
- The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

## PARTICIPANT DECLARATION

- All persons who have completed the PAR-Q+ please read and sign the declaration below.
- If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME \_\_\_\_\_ DATE \_\_\_\_\_

SIGNATURE \_\_\_\_\_ WITNESS \_\_\_\_\_

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER \_\_\_\_\_

For more information, please contact

[www.eparmedx.com](http://www.eparmedx.com)  
Email: [eparmedx@gmail.com](mailto:eparmedx@gmail.com)

**Citation for PAR-Q+**  
Warburton DER, Jamnik VC, Bredin SSD, and Gledhill N on behalf of the PAR-Q+ Collaboration. The Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and Electronic Physical Activity Readiness Medical Examination (ePARmed-X+). *Health & Fitness Journal of Canada* 4(2):9-23, 2011.

### Key References

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The PAR-Q+ was created using the evidence-based AGREE process (1) by the PAR-Q+ Collaboration chaired by Dr. Darren E. R. Warburton with Dr. Norman Gledhill, Dr. Veronica Jamnik, and Dr. Donald C. McKenzie (2). Production of this document has been made possible through financial contributions from the Public Health Agency of Canada and the BC Ministry of Health Services. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada or the BC Ministry of Health Services.

## Appendix D: Injury History Questionnaire

### Screening/Knee-Injury History Questionnaire

Name: \_\_\_\_\_

Email: \_\_\_\_\_

(used to contact regarding eligibility for study participation)

1. What is your current age? \_\_\_\_\_ years
  
2. Women only: Are you pregnant? \_\_\_\_\_
  
3. Have you ever had a lower extremity injury? (*hips, upper leg, knees, calves/shins, ankles, feet*) \_\_\_\_\_

3a. If you had more than one lower extremity injury, please list what and when:

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4. When was your last lower extremity injury? \_\_\_\_\_
  
5. What treatment did you receive to correct the injury? \_\_\_\_\_

---

6. Do you have any lasting effects or remaining issues from the injury? \_\_\_\_\_

6a. If yes, what \_\_\_\_\_

7. Do you usually wear any protective equipment to help stabilize the area you injured? \_\_\_\_\_

7a. if yes, what? \_\_\_\_\_

Q#	Question	response for INCLUSION
1	What is your current age?	18-25 yrs
2	Women only: Are you pregnant?	No
3/3a	Have you ever had a lower extremity injury?	No; or injuries that did not result in complete rupture/tear that required surgical intervention.
4	When was your last lower extremity injury?	Answers that are outside of 12 months.
5	What treatment did you receive to correct the injury?	All treatments outside of surgery/full reconstruction
6/7a	Do you have any lasting effects or remaining issues from the injury?	No; or minor aches
7/7a	Do you usually wear any protective equipment to help stabilize the area you injured?	No; or basic compressive sleeve

## Appendix E: Subject Demographic/Training History Survey

### ***Subject Demographics/Training History***

Participant Number \_\_\_\_\_

1. Age: \_\_\_\_\_
2. Gender: \_\_\_\_\_
3. Height (m): \_\_\_\_\_
4. Weight (kg): \_\_\_\_\_
5. Body Fat (%) \_\_\_\_\_
6. School Year: \_\_\_\_\_
7. Played High School Sports? \_\_\_\_\_
  - 7a. if so which sports? \_\_\_\_\_
8. In the last month how often does the subject exercise outside of ROTC Physical Training a week (hrs.)? \_\_\_\_\_
  - 8a. Primarily exercise type: resistance training or endurance training (*circle*)
  - 8b. Description of type: \_\_\_\_\_

# Appendix F: IU-HSU-Protocol

Effect of Eccentric Training Intervention on Performance During the Spring, Drag, Carry Event of the Army Combat Fitness Test

Jacob Davel, Graduate Student Indiana University (Co-Investigator)

1025 E 7th St, Bloomington, IN 47405

Principal Investigator: Dr. Brian Moscicki

Kinesiology Department

School of Public Health Indiana University

Table of Contents:

Study Schema

Background & Rationale

Objective(s)

Primary Objective

Secondary Objective

Outcome Measures

Primary Outcome Measures

Secondary Outcome Measures

Eligibility Criteria

Inclusion Criteria

Exclusion Criteria

Study Design

Enrollment/Randomization

Study Procedures

Study Calendar

Reportable Events

Data Safety Monitoring

Study Withdrawal/Discontinuation

Statistical Considerations

Data Management

Privacy/Confidentiality Issues

Follow-up and Record Retention

References

#### Abbreviations

This page is optional. The list below includes some common abbreviations. However, this list should be customized for each protocol (i.e., abbreviations not used should be removed and new abbreviations used should be added to this list).

AE	Adverse Event
ACFT	Army Combat Fitness Test
BW	Body Weight
RoM	Range of Motion
ROTC	Reserve Officer Training Corps
RPE	Rate of Perceived Exertion
SDC	Sprint Drag Carry
IRB	Institutional Review Board
IU	Indiana University
LB	Pound
NC	Nordic Complex
PI	Principal Investigator
SAE	Serious Adverse Event
TBD	To Be Determined
US	United States

#### 1.0 Background & Rationale

Today's military Soldiers are required to be tactical athletes. In the last few years, the military has designated money and resources to improve the efficiency of Soldier training and provided information for enduring the holistic mission. However, the military is still in its infancy as far as fully implementing a

sustainable plan to not only optimize Soldier performance but continue to reduce injuries that have plagued the military for decades. Musculoskeletal injuries continue to be not only an issue to unit readiness but a deep financial hole in the government's pocket due to the amount of disabilities because of injuries sustained during service. (Jones et. al, 2005) These MSI injuries are not only the leading cause of injury for military service members but are 2-3 greater than the next leading category (mental illness). (Zambraski et. al, 2012) In 2006 alone, there were over 743,500 injury-related musculoskeletal conditions. The leading cause of these injury-related musculoskeletal conditions was classified as inflammation/pain (overuse) (82%), followed by joint derangements (15%) and stress fractures (2%). The knee/lower leg (22%), lumbar spine (20%), and ankle/foot (13%) were leading body region categories. (Hauret et. al, 2010) It is imperative that military leaders train their Soldiers with the same dedication to injury prevention as they do to performance. Injuries are a part of the prudent risk; however, some are preventable, and a lack of education or implementation plans are not acceptable for a population you are asking to continue to be in areas of imminent danger. As our Soldiers have increased their training loads without adequate training progression it has led to a high prevalence of lower extremity injuries. In 2019, Army Medical surveillance reports indicated that 72% of all newly diagnosed injuries for active-duty Soldiers were a result of overuse musculoskeletal injuries. (Hardinson et. al, 2022)

As a result of the Soldier injury rate affecting readiness, The Army rolled out their new “Army Combat Fitness Test” in 2019. This was the first new test in over 40 years (shaul et. al, 2017). The 6-event test consists of a maximum 3-repetition hex bar deadlift, a standing power throw with a 10lb medicine ball, the sprint-drag-carry event, which is a 250-meter shuttle that includes sprinting, dragging a 90lb sled, side shuffling, hand-carrying two 40lb kettlebells, and finally sprinting gain. The 5th event is the maximum effort plank. This event replaced the original 5th event, the leg tuck in April of 2022. While the manual has not been updated to reflect this event the new grading rubric do reflect the change, Finally, the test finishes with the classic 2-mile run. This new test was developed to not only assess the aerobic muscular endurance of Soldiers but also the anaerobic power output in explosive movements. These new movements have come with a risk of an increase in musculoskeletal injuries. While there are several issues to be addressed to reduce this high rate of injury, starting with proper development of the skeletal muscle can be accomplished with proper education, training load, and recovery.

One recommended modality to improve muscular strength and reduce injuries in the low back and lower extremities is eccentric training. The concentration of the eccentric phase of movements has been shown to increase fascicle length and cross-sectional area in addition to being a potent stimulus for enhancements in the muscle-tendon unit. (Douglas et. Al, 2017) An additional risk associated with lower extremity injuries is the lack of symmetry of the hamstring and quadriceps. This is often referred to as the H: Q ratio (Ribeiro-Alvares et. Al, 2018). To maximize the benefit of the eccentric training on the lower extremity equal focus must be given to the posterior chain as is given to the anterior of the major lower muscle groups such as the quadriceps. The Nordic hamstring curl is a common eccentrically focused exercise aimed at developing the posterior chain, by combining the exercise with the Reverse Nordic Curl, which focuses on the quadriceps and hip flexors, a subject can achieve symmetry in their training goal.

2.0 Objective(s)

Primary Objective

Determine if Body Weight Eccentric Training Intervention has tangible carry over to the sprint drag carry

## Secondary Objective

Examine if Nordex Complex Training Intervention reduces musculoskeletal injuries during the Army Combat Fitness Test

### 3.0 Outcome Measures/Endpoints

#### Primary Outcome Measures

Examine performance during the ACFT and specifically, the time improvement in the sprint drag carry event between pre and post-testing as a result of different interventions.

#### Secondary Outcome Measures

Observed injury rate between groups is significant.

Measurements taken will be total time to complete the Sprint Drag Carry Event, the 2-mile run and total score on the ACFT. The Sprint Drag Carry Event consists of ten 25-meter lengths that include 50m of sprinting, 50m of a 90-lb sled drag, 50m of lateral shuffling, 50m of hand carrying two 40lb kettlebells and 50m of sprinting.

### 4.0 Eligibility Criteria

#### Inclusion Criteria

List the criteria:

Between the Ages of 18-25

ROTC cadets at Indiana University

Consent to the protocol discussed

Knee questionnaire includes responses on questions 3/3a of No; or injuries that did not result in complete rupture/tear that required surgical intervention.

Knee questionnaire question 4, Answers that are outside of 12 months.

Knee questionnaire question 5, All treatments outside of surgery/full reconstruction.

Knee questionnaire question 6/7a, No; or minor aches,

Knee questionnaire question 7/7a, No; or basic compressive sleeve.

#### Exclusion Criteria

List the criteria:

Positive answer on section 2-4 of the PARQPLUS

Unable to perform any of the movements within the intervention without pain

Female who is pregnant

## 5.0 Study Design

The design of this study is a repeated measures collection in a field environment from two groups (Nordic Complex and Eccentric Tempo Body Weight Squat). All participants will be randomized into one of these two groups. The participants will undergo three data collections a week for six weeks totaling 18 training sessions in addition to pre and post Army Combat Fitness Test. This will be analyzed using a T-Test comparing between groups.

## 6.0 Enrollment/Randomization

Potential participants will be recruited after the conclusion of one of routine physical training sessions in person in which they are given details of the study. Those who express interest will complete the screening questionnaires (PARQPLUS and knee injury questionnaire) that are referenced the Investigator Script document. The target population will be cadets within the ROTC population. All consults will be done individually and privately. All subjects will be provided with a subject number from a random number generator once they qualify for the study. In addition, they will be randomly assigned to one of the two groups listed above. All personal data will be stored in the school of public health and one hard copy of subject names will be kept secure not to be used during data collection.

## 7.0 Study Procedures

On visit number 1, all participants will complete the questionnaires (subject demographic/training history) and have their height, weight, and body composition measured at Hayes Track (Indiana University Track and Field facility) or Gladstein Fieldhouse (indoor track and field facility) due to inclement weather.

Height – A stadiometer will be used to collect standing height. Participants will be asked to remove their shoes prior to the assessment. Height will be obtained to the nearest cm.

Bioelectrical Impedance (BIA)- Participants will remove their shoes and socks to complete this assessment. They will be asked to stand on a BIA scale (Tanita) and hold two electrodes in either hand. The duration of this test is anticipated to take approximately 10 seconds per reading. Two readings will be taken and then averaged for measures of body weight (kg or lbs.), body fat percentage (%), and total body water (%). Subjects will be provided with a standard set of hospital scrubs to wear for body weight and composition measures.

In addition, on study visit 1: The participant will be shown an example of the parameters of the Nordic Complex and the Eccentric Tempo Body Weight Squat by a member of the research team. The researchers will determine the participants' ability to conduct the Nordic Complex and the Eccentric

Tempo Body Weight Squat. To start the assessment of the Nordic Complex, the participant will then be instructed to assume the starting position of tall kneeling with an upright trunk and their toes pointed, with the top of their foot ideally resting on the ground. They will begin the movement by lowering their upper trunk backward while maintaining a straight torso. Shins will remain fixed on the ground, and they will lower until they either reach the back of their calves or their maximum range of motion. They will then return to the starting position. A partner will hold the participants' ankles while they lower their bodies forward resisting the urge to fall to the ground. They will lower as slowly as they can until they feel the need to brace themselves with their hands extended. They will then push with a force off the ground back to the starting position. This is considered one repetition of the Nordic Complex.

For the Eccentric Tempo Body Weight squat, participants will begin standing with their feet just outside shoulder width. At the command begin, they will lower the body until their upper leg is parallel to the ground. The lowering portion of the squat should be completed in three seconds. Once they reach the bottom of the squat, they will then stand back up to the starting position at their own pace.

Disqualifying criteria for participation in this study are limited to the participant experiencing pain throughout any of the movements. The participants' range of motion during the movements is not a disqualifying criterion for the bodyweight squat including an inability to complete 15 repetitions of the movement due to injurious pain. This is considered one repetition of the Eccentric Tempo Body Weight.

On study visit 2, the participants will conduct their initial testing of the Army Combat Fitness Test. Participants will be assigned one of three days to conduct the event due to the time required to take the test, supplies needed, and personnel available. On the day of their test, they will be given a small device called an accelerometer that will measure their movement during the ACFT. They will then be taken to one of the lanes to be graded by study personnel in accordance with the Army ACFT manual. The participants' tests will be administered in accordance with the U.S. Army Combat Fitness Test Field Manual test issuance script. They will be asked to do their best in all events. After completion of the initial ACFT, they will not be told their initial scoring time, only whether they maxed the scoring or failed completely the test to the standards stated above. This will be done to ensure those who are either close to maxing the event or significantly far from it do not alter their effort during interventions. There will be no re-testing for any events in this initial pre-study test.

The participants will be randomly assigned to one of two groups (Nordic Complex or Eccentric Body Weight Squat). Both groups will complete the prescribed ROTC physical training (3 days a week for 6 weeks) from the attached training plan. Cadets within the Army ROTC program conduct physical training every Monday, Wednesday, and Thursday from 0600-0700 as part of their required curriculum. The intervention that includes the two groups of Nordic Complex or Eccentric Body Weight Squat is the only addition to the already prescribed training plan. This training should take no more than 10 minutes following the completion of mandatory training. Upon completion of training, they will move to the testing area to execute one of two training interventions for the assigned group. They will either complete 3 x 15 repetitions of the Eccentric Tempo Body Weight squat or 3 x 5 repetitions of the Nordic Complex. Rest time between each set will be 2:00min. At the completion of each set, they will be asked to report their rate of perceived exertion (RPE) for both full bodies as well as local exertion (focusing on their legs). We will use the Borg scale of 6-20 to report the participant's exertion to the investigator that will complete the data collection for that day. If at any time the participants feel injurious pain or are unable to complete the repetitions, they will note the number of completed repetitions to the investigator and that will complete their data collection for the day. They will then consult with the IU

Training Staff to determine if they are medically eligible to continue with data collection at the next scheduled date. If they are recommended for further treatment that could result in missing more than the allotted data collections, they may be withdrawn from the study.

The total training program will last six weeks and consists of three training sessions a week for a total of 18 training sessions. The participants are authorized to miss (3) total training sessions but not two in the same week. If they are unable to complete two training sessions back-to-back, they will be removed from the study.

Following the 6th week of training, the participants will have their body composition assessed a second time and be asked to complete the ACFT again. The protocol will be the same as the first attempt in accordance with the ACFT manual. They will again be asked to wear an accelerometer for this second test

All measurements will be taken in the field utilizing physical data collection. Accelerometers will be affixed to the participants during data collection and will be observed after collection.

All participants will perform their interventions immediately following already prescribed physical training. They will be expected to provide up to 15 minutes following the completion of training to complete the prescribed intervention. Each subject will provide data by completing the exercises and reporting their RPE for lower extremities and full body. They will also have data collected in the form of total time to complete the sprint drag carry event.

## 8.0 Study Calendar

Week 1- Enrollment, Demographics, Familiarization with exercises, and initial ACFT

Week 2-7- Daily physical training followed by one of two prescribed interventions from the training plan below.

Week 8- Final ACFT for post-test.

## 9.0 Reportable Events

The PI will report any adverse event or unanticipated problems involving risk to the IU IRB through the Quali Protocol system. Collection of adverse and serious adverse events will begin to be collected at the time of consent. Any event that requires prompt reporting to the IU IRB per the IU HRPP Policy on Reportable Events will be reported within five business days in compliance the IU HRPP Policy. Minor noncompliance and minor protocol deviations not meeting the requirements for prompt reporting will be reported at time of protocol renewal.

## 10.0 Data Safety Monitoring

Dr. Moscicki will work with Cpt. Davel on maintaining data safety and management throughout the study. All data will be either stored as a physical copy in Dr. Moscicki's office and locked cabinet or digitally stored on password protected/network secure university systems.

All participants will be assigned a participant number and will be labelled with this number throughout the study. No personal participant identifiers will be used on data collection sheets or in spreadsheets for this study.

#### 11.0 Study Withdrawal/Discontinuation

Subjects who wish to withdraw from the study can do so at any time. Subjects will inform the research personnel they no longer wish to participate in the study. Once confirmed all personal information and data collection will be destroyed.

Each subject is responsible for attending all sessions available (18) if a subject is unable to attend a session for any reason they will coordinate with the investigator via email or verbally. If a subject misses more than 3 sessions total or two in a row, they will be removed from the study.

#### 12.0 Statistical Considerations

Previous research of the Nordic Hamstring Eccentric training in trained soccer players has demonstrated effect sizes of 0.86 and 0.80 on indicators of hamstring injury (eccentric hamstring work and Quadriceps to Hamstring strength ratio respectively). Inputting this effect sizes into G Power software, the sample size was recommended to be between 34 and 42 based on the above-mentioned effect sizes. The target sample size in this study is 30 total participants randomly separated into 2 groups of 15. We have chosen 30 participants as this number is approximately 1/3 to 1/4 of the ROTC training group though we will take all volunteers into the study and report any increases in participation.

SPSS software will be utilized for analysis. We will use a T-test for our statistical analysis to compare pre- to post- ACFT scores and body composition changes. We will also use a Repeated measures ANOVA in the assessment of the average weekly Whole Body and Local Leg Rates of Perceived Exertion.

Statistical analyses will be conducted on validated statistical software (e.g. SPSS) and results will be reported through traditional scientific outlets such as peer-reviewed journals and presentations. All analyses will be done without the use of any identifying features to individuals enrolled (e.g. use of ID codes, saving electronic data using ID codes rather than subject name).

A participant's data will not be utilized in the analysis if the participant does not complete both the pre- and post- ACFT assessment. A participant's weekly RPE data will still be assessed if they miss one training session in a single training week but will not be assessed if the participant misses 2 training sessions in the same week.

#### 13.0 Statistical Data Management

Primary data collection will be done on paper and stored in the office of Dr. Brian Moscicki in the School of Public Health Kinesiology department. The hardcopy data will be input into digital files will be maintained on password protected/network secure university servers and shared between Dr. Moscicki and Jay Davel. We will use SPSS on a university computer for all statistical analyses.

#### 14.0 Privacy/Confidentiality Issues

All possible efforts will be made to keep the participants personal information confidential. We cannot guarantee absolute confidentiality. The participants personal information may be disclosed if required by law. Their identity will be held in confidence in reports in which the study may be published. Data will be recorded with numerical identifiers, hardcopy forms will be stored securely in Dr. Moscicki's office in the School of Public Health on the IU campus and will be made available only to people involved with the study unless the participants specifically give permission in writing to do otherwise. No reference will be made to verbal or written reports which could link participants to this study.

#### 15.0 Follow-up and Record Retention

Research records will be maintained for a minimum of three years and physical records will be destroyed via shredding and confidential recycling on IU's campus.

#### 16.0 References

Bigelman, K. A., East, W. B., Thomas, D. M., Turner, D., & Hertling, M. (2019). The New Army Combat Fitness Test: An Opportunity to Improve Recruitment and Retainment. *Obesity* (Silver Spring, Md.), 27(11), 1772–1775. <https://doi.org/10.1002/oby.22619>

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## Appendix G: Borg Scale Handout

Borg Scale of Perceived Exertion		
6	No exertion	How you feel when watching TV or reading a book.
7	Very, very light	Little or no effort.
8		
9	Very light	
10		
11	Fairly light	
12		Target range: How you should feel with most exercise or activity.
13	Somewhat hard	
14		
15	Hard	
16		
17	Very hard	How you felt with the hardest work you have ever done.
18		
19	Very, very hard	
20	Max exertion	Don't work this hard!

## Appendix H: Data Collection Sheet

### Eccentric Research Study *Data Collection Sheet*

Participant number: \_\_\_\_\_

Training Date: \_\_\_\_\_

Group (Nordic Complex vs. Eccentric Tempo Body Weight Squat)

Participant completed physical training that day: YES/NO (*circle one*)

#### Intervention:

##### 1. Nordic Complex:

Set 1: Repetitions completed \_\_\_\_/5 (2:00 min rest time)

Set 2: Repetitions completed \_\_\_\_/5 (2:00 min rest time)

Set 3: Repetitions completed \_\_\_\_/5 (2:00 min rest time)

Total time to complete intervention: \_\_\_\_\_

Localized Relative Perceived Exertion: \_\_\_\_\_(6-20)

Whole Body Relative Perceived Exertion: \_\_\_\_\_(6-20)

##### 2. Eccentric Tempo Body Weight Squat:

Set 1: Repetitions completed \_\_\_\_/15 (2:00 min rest time)

Set 2: Repetitions completed \_\_\_\_/15 (2:00 min rest time)

**Set 3: Repetitions completed \_\_\_\_/15 (2:00 min rest time)**

**Total time to complete intervention: \_\_\_\_\_**

**Localized Relative Perceived Exertion: \_\_\_\_\_(6-20)**

**Whole Body Relative Perceived Exertion: \_\_\_\_\_(6-20)**

**Did an adverse event occur (check one):  Yes  No**

**Signatures of lab personnel present for data collection:**

\_\_\_\_\_

**Data Collection Notes:**

\*example items: reasons data collection could not be completed (e.g. subject unable to complete repetitions/  
sustained injury), circumstances of adverse event (if applicable), protocol deviations.

\_\_\_\_\_

\_\_\_\_\_

## **Author's CV**

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#### **EDUCATION**

Indiana University-Bloomington

Bloomington, IN

*Master of Science-Kinesiology*

Est. Grad May '23

Current GPA: 4.0

University of Wisconsin-Oshkosh

Oshkosh, WI

*Bachelor of Science in Biology-Pre-Medicine*

December 2014

Cumulative GPA: 3.0

**PROFESSIONAL EXPERIENCE**

United States Army (>8yr)

Bloomington, Indiana

*Captain, Engineer Officer*

January 2015 – Present

- Currently serving as an Assistant Professor of Military Science within the Army ROTC department at Indiana University. Responsible for leadership development of the Sophomore and junior classes. Coach of the Ranger Challenge team (Varsity Sport).
- Commanded the United States Army Engineer Regiment's premier leadership school, Sapper Leader Course; managed 75 Soldiers and \$5.5 million of vehicles and equipment; supervised elite training in various high-risk events such as Demolitions, Mountaineering, Water Operations, and Small Unit Tactics.
- Primary Instructor for the United States Army Engineer School Officer Basic Course; responsible for the instruction of all leadership aspects of the United States Military and basic Soldiering skills; course load of 800 Engineer Lieutenants per year. Earned US Army Instructor Badge.
- Served as the Executive Officer to three companies including the US Army's Pacific Command's only Engineer Construction Company: responsible for coordinating plans, resourcing, and the execution of projects on the Island of Oahu in excess of 5 million dollars.
- Deployed to South Korea for 7 months in support of Task Force Ready as the first Echelons Above Brigade (EAB) on the peninsula; trained the Republic of Korean Army on threat ordinance clearing and mine detection.
- Placed in the top .05% of all Reserve Officer Training Corps Cadets on the National Order of Merit List.

Port Washington Parks and Recreation Department (7yr)

Port Washington,

WI

*Head Lifeguard-Lifeguard-Lifeguard Instructor-Swim Instructor*

*June 2006 – August 2013*

- Managed 20 Lifeguards and 15 Pool staff; instructed 3 Lifeguard Courses; served as a lifeguard for five years prior to being selected to manage day-to-day operations for Pirates Hollow Waterpark.

### **SKILLS AND ACCOMPLISHMENTS**

- *Technical Certifications:* Tactical Strength and Conditioning Facilitator (TSAC-F), Certified Senior Army Instructor, Army Rappel Master, Lifeguard & First Aid Instructor, Distinguished graduate of US Army Engineer Captains Career Course and Basic Officer Leader Course
- *Tactical & Leadership:* Graduate of US Army Ranger School and US Army Sapper Leader Course
- *Languages:* English (primary); Spanish (5 years of study)
- *Personal:* expert communicator; highly organized; socially astute; goal-oriented; attentive to detail

### **PERSONAL INTERESTS**

- Family, hunting, weightlifting; competitive sports; healthcare study; reading.
- Married 6-years (Kathryn), three daughters (Aubrey-4, Delaney-4, Cecilia-2), two dogs (Wesson & Remi)