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Research Article

Incorporating Training Prescription from a Countermovement Jump-based Algorithm Does Not Improve Jump Performance

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Abstract

Countermovement jump (CMJ) testing is a commonly used, effective tool for monitoring performance, neuromuscular fatigue, and injury risk. Force plates can provide information about jump performance including power, explosiveness, and interlimb asymmetry. Embedded human performance (HP) teams focus on preparing military personnel to meet the physical demands of their occupations, and with the implementation of CMJ monitoring; they can work towards eliminating the risk of musculoskeletal injuries (MSKI). The purpose of this study was twofold: 1) Determine whether the intervention exercises prescribed by Sparta Science training program changed an individual's jump performance over a 10-week training program and 2) Evaluate how Sparta strength training recommendations impacted other performance metrics over the training program. This study included 31 active-duty Air Force personnel who completed a 10-week, concurrent training program with pre- and post-testing. Sparta jump height increased by 2.11 centimeters on average. Lower body anaerobic capacity improved as evidenced by significant lower body wingate relative (W/kg) (p=0.022) and absolute power (W) (p=0.045) increases from pre- to post-testing. The results of this study indicated that practitioners are not likely to achieve optimal results for either injury risk or jump performance by following Sparta's training suggestions. Instead, these results indicate that the appropriate training program recommendations include focus on the specific needs of an individual, to include strength, power, and force-developing exercises to elicit optimal jump and performance metric outcomes.

Keywords

Countermovement, Jump, Performance

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1. Introduction

Embedded human performance (HP) teams focus on preparing military personnel to meet the physical demands of their occupations. In recent years, the skyrocketing costs of musculoskeletal injuries (MSKI) has led HP teams to work on decreasing injury risk while preparing individuals for peak performance [1, 2]. This is a difficult task. MSKIs are responsible for 60% of limited duty days in the U.S. Army, cost billions of dollars for active-duty military personnel and restrict operational duty days more than any other cause including combat-related injury, illness, accident, or other factors [1-4]. In military populations, the majority of MSKIs occur at the lower back and below [2]. Therefore, establishing the best practice for optimizing an individual's performance, while mitigating injury in the lower extremities has become a necessity.

Countermovement jump (CMJ) testing is a commonly used, highly effective tool for monitoring performance, neuromuscular fatigue, and injury risk in athletic and tactical populations [5-8]. A correlation between CMJ performance and mission-specific performance in the military setting has also been theorized [9]. Neuromuscular fatigue is the reduction of maximal force that muscles can generate, brought on by exercise [10], and has been associated with lower vertical jump height and diminished duty readiness [6]. Increased neuromuscular fatigue can lead to increased injury risk [10], due to its effect on disrupted motor control, neuromuscular activation delay, and increased torque and shear forces on ligaments, thereby adversely impacting joint stability [11]. Neuromuscular fatigue has also been associated with impairments in balance, posture, and proprioception [11].

Traditionally, force plates have been used almost exclusively in research labs due to cost, space requirements, and trained operators for analyzing the data. However, many force plate companies are moving towards solutions for cost efficacy, improved portability, improved user interface operations. Now, many tactical HP teams have integrated CMJ testing into their programs. The addition of force plate measurements in CMJ screening has the opportunity to provide useful information regarding performance, neuromuscular fatigue, MSKI risk, and job performance. Performing CMJ testing on force plates provides additional information about jump performance including power, explosiveness, and interlimb asymmetry [12]. Kinetic measures such as impulse, rate of force development (RFD), and landing force asymmetry require kinetic measurement tools. They have also been linked to increased MSKI risk and operational performance for military personnel participating in a 5-week individualized training program [1]. Commercial force plate companies use proprietary algorithms to provide greater insights for users. Those same companies are striving to measure jump performance accurately while using machine learning algorithms to provide additional insights for clinicians, and to differentiate them from their competitors [13].

One option, sold by Sparta Science (Menlo Park, CA), is a single plate system that administers a jump test and derives associated scores. The scan requires individuals to complete three max-effort CMJ with arm swing repetitions and produces an overall jump score, called the "Sparta Score", which is intended to quantify dynamic movement efficiency [14]. Then, a risk classification index is derived from the Jump Scan using a proprietary algorithm to quantify MSKI risk [15]. Based on the Jump Scan, Sparta also generates a "movement signature" classification and provides workout suggestions to help the individual improve jump performance. Figure 1 is an example of force-time curve with Sparta's major performance metrics highlighted. The "movement signature" is determined based on the jump phase with the poorest relative performance [16].

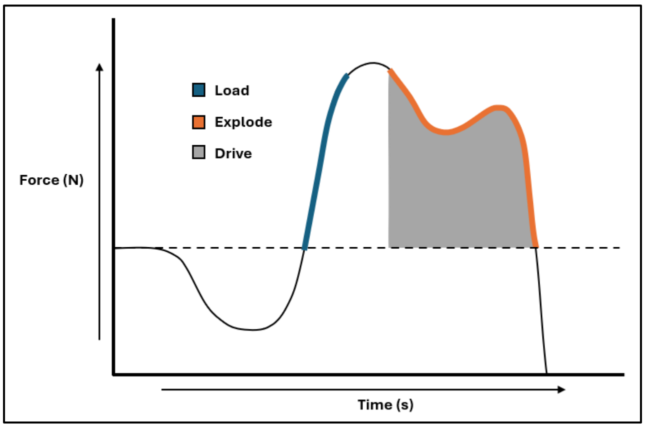

Figure 1. *Example Force Time Curve with Major Sparta Performance Metrics Highlighted.*

It is understood that stronger individuals jump higher and are injured less often [17, 18]. Sparta training is specifically trying to improve the phase of the jump that is the weakest, therefore, it is targeting muscles to execute that part of the jump. However, there is no evidence that the training proposed results in increased jump height regardless in increased strength of particular muscle groups. Therefore, the primary purpose of this study was:

1) Determine whether the Sparta-prescribed training changed an individual's jump performance over a 10-week program.
2) Evaluate the effect of Sparta strength training recommendations on other performance metrics after 10 weeks.

2. Materials and Methods

2.1. Subjects

This study included 31 active-duty Air Force personnel at the STRONG Lab, 711th Human Performance Wing, Air Force Research Laboratory (AFRL), Wright-Patterson Air Force Base, Ohio. The subjects ranged in age from 18-45 years (men: n=27, age = 34.4±5.3 years, height = 176.86±10.78 cm, body mass = 88.54±17.14 kg; women: n=4, age = 32.7±4.6 years, height = 165.10±5.49 cm, body mass = 77.98±7.48 kg). To participate in the study, individuals must be active duty, national guard, or reserves, without fitness test or duty restrictions, and not on a medical profile. Subjects were excluded if they were currently on a medical or pregnancy profile, currently breastfeeding, taking prescribed blood pressure medication, undergoing hormone therapy, or suffering from a MSKI and/or neurological or cardiorespiratory disease that might limit their ability to engage in daily resistance and/or aerobic exercise. Subjects were informed of the risks and benefits of the study and signed the institutionally approved informed consent document. All procedures were conducted according to the Declaration of Helsinki guidelines and approved by the Institutional Review Board of the Air Force Research Laboratory (#FWR20210097). Each subject completed a 10-week training program in addition to performance testing pre and post. Based on their initial jump classification, individuals were prescribed a training program including exercises recommended to improve the weakest phases of their jump.

2.2. Procedures

2.2.1. Performance Testing

During pre-testing and post-testing, subjects were asked to perform a testing battery that began with a warm-up and was comprised of various jump, strength, power, and endurance performance tests. This testing took place over a 3-day period for both pre- and post-testing.

2.2.2. Jump Testing

Participants completed jump testing on the first day of pre- and the last day of post-testing assessments. They performed 3 CMJ repetitions on a Sparta Science force plate, measuring at 1,000 Hz and 3 CMJ repetitions on a set of VALD Force Decks (Newstead, Queensland, Australia), measuring at 1,000 Hz per force plate. The order of these test was randomized to mitigate fatigue effects, and the same procedures were used for jump testing on the Sparta and VALD plates. However, it is important to note that the Sparta uses a single force plate while the ForceDecks are a dual plate system.

Prior to testing, the force plates were zeroed. Subjects began by standing upright and as still as possible while the application recorded their weight. Then, they began a CMJ with arm swing by dropping down to a self-selected countermovement depth, using a squatting motion, followed immediately by jumping as high as possible. Verbal encouragement, which emphasized external cuing ("push explosively away from the ground", "reach toward the ceiling"), was provided to ensure that maximal effort was given during each jump attempt. Subjects completed three successful trials each testing day.

The average of participants' three jumps on day one of pre-testing and the average of their three jumps on the last day of post-testing were analyzed. In this study, the authors relied on the force plate software, both Sparta and VALD, to extract the variables of interest; for some metrics proprietary algorithms were used to calculate, and others were simply raw metrics captured from force plate output. All performance testing completed, was collected in-lab by STRONG Lab personnel and the data was subsequently stored on a cloud-based data management system.

2.2.3. Other Performance Tests

In addition to jump testing, individuals completed other tests of lower body power and strength including a lower body wingate anaerobic test, isometric mid-thigh pull (IMTP), and standing long jump.

2.2.4. Lower Body Wingate Anaerobic Test

The lower body wingate anaerobic test was completed on a Monark 849E Cycle Ergometer (Vansbro, Dalarnas Lan, Sweden). This test was a 30-second all-out exhaustive ergometry test where the athlete pedaled against a resistance load (i.e., brake weight) that was set at 7.5% body mass. The power output was calculated throughout the test by the number of revolutions that athlete can achieve on the ergometer during those 30 seconds. Peak power recorded was the maximal power output achieved for 5 seconds of the test, typically the first 5 seconds. The average power was recorded and averaged over the entire 30 seconds of the test.

2.2.5. Isometric Mid-Thigh Pulle (IMTP) Test

IMTP is an efficient strength testing method to evaluate an individual's maximal force production [5]. Three maximal effort IMTP trials were performed with the individual standing on VALD Force Decks plates within a Kairos rig (Alameda, California), performance metrics were averaged over 3 trials. The force plates were zeroed with a foot on each plate. The bar height was set at a midthigh height with slight knee bend, and kept constant throughout a subject's testing. Individuals were instructed to generate their max force as quickly as possible and hold for 3 seconds. Two warm-up trials were performed, one at 50% maximum effort and one at 75% maximum effort. These were performed just prior to the three 100% maximum effort trails. The peak vertical force from the maximum effort trials is reported.

2.2.6. Sparta Jump Classification

Participants were assigned a training focus based on their individual Sparta bucket classification. Sparta buckets are based off three jump variables: Load, Explode, and Drive, which make up an individuals' "Jump Signature" [14]. Load is the ability to generate force quickly and efficiently, explode is the ability to transfer forces effectively, and drive is the ability to apply forces efficiently [14]. In other words, load refers to the primarily eccentric component of movement, explode describes the transition between eccentric and concentric force during the squat, and drive is the concentric phase that accelerates the individual into the air during the flight phase of the jump. The Sparta algorithm classifies individuals based on what it identifies as the weakest areas of their jump performance. For example, an individual in the load bucket is theorized to benefit from improving their load phase or ability to generate force quickly and efficiently. Again, refer to figure 1 above to view a Sparta force-time curve and identify where each of the three metrics occurs during a countermovement jump; subjects were placed into the appropriate bucket based on individual strengths and weaknesses.

2.2.7. Training

The training consisted of a 10-week, concurrent training program with five training days per week. The days of the week were structured with high intensity interval training (HIIT) on Monday, strength training on Tuesday and Thursday, and cardiorespiratory training on Wednesday and Friday. All groups conducted similar HIIT sessions on Monday consisting of a six exercise "as many rounds as possible" style circuit that progressed exercises with similar muscle groups and total volume over the 10 weeks (Table 1). All groups were prescribed the same cardiorespiratory training on Wednesday and Friday that consisted of self-selecting the modality (elliptical, rower, treadmill, or bike) for intensity and time. Participants were encouraged to get one seated and one standing cardio modality per day. Following the cardio sessions core exercises, such as V-ups, crunches, cross-crunches, full planks, elbow planks, and side planks were performed. Strength training sessions all started with a general dynamic warm-up, followed by a warm-up specific to the movements assigned for that day. Each session was a total body day, starting with a primary upper body lift (e.g., barbell bench press), followed by the lower body exercises recommended by Sparta (Table 1). For example, to improve "explode" characteristics, Sparta recommends trap bar deadlift and jump squat as strength movements and non-countermovement jumps, and pogo jumps for other exercises. Dynamic, explosive movements like jumps were performed before loaded strength movements. Following the main total body lifts, secondary lifts and accessories for the upper and lower body (e.g., inverted row and dumbbell incline bench press) were performed. Throughout the training program, there was variation in exercises and volume to provide the subjects with the ability to achieve optimal adaptations. Exercise session details were recorded using the Bridge Athletic (San Francisco, CA) application, and all participants included in this analysis achieved an 80% attendance rate.

Table 1. *Example of Sparta Prescription Suggestions.*

Low Load	Low Explode	Low Drive
Front squat / Back Squat	Trap Bar Deadlifts	Overhead Squat
Push Press	Front Squat	Clean High Pull
Power Clean	Jump Squat	Single Leg RDL
Heavy Sled Push	Pogo Jumps	Broad Jump(s)
Forward Bound	Lateral Bounds	Vertical Jump

Notes: RDL=Romanian Deadlift

2.3. Statistical Analysis

All jump testing was analyzed using Sparta Science software and VALD software (Newstead, Queensland, Australia), and VALD software was also used for the IMTP analysis. Descriptive statistics were generated with Microsoft Excel (version: 2202) (Redmond, WA). Other statistical analyses were performed using R software (version: 4.3.3) (Free Software Foundation, Boston, MA). Repeated measures analysis of variance (ANOVA) was conducted on jump and performance metrics. The Tukey post hoc analysis was only run on features with statistically significant differences (p-value < 0.05) determined by the ANOVA.

After the initial analysis, individuals were grouped as "responders" or "non-responders" based on their relative jump performance at pre- and post-testing utilizing their results from their Sparta Science jump height. Individuals in the top 50% of jump height increase were considered "responders" and those in the lower 50% were considered "non-responders." The same statistical analyses described above were then performed on these groups.

3. Results

3.1. Jump Testing

Multiple jump testing metrics differed significantly from pre- to post-testing (Table 2). Interestingly, both jump height from Sparta (p=0.000) and jump height from ForceDecks (p=0.002) yielded a significant difference between pre- and post-testing, but in different directions. Sparta jump height recorded an average increase of 2.11 centimeters and ForceDecks recorded an average decrease of 2.77 centimeters. Raw jump values that exhibited statistically different values were concentric impulse (p=0.008), max velocity (p=0.007), max power (p=0.004), and countermovement depth (p=0.021).

As for metrics derived from Sparta, drive and injury risk were the only two variables with significant differences. Both increased from pre- to post-testing.

Table 2. *Pre- and Post-Testing Jump Data.*

Variable	Pre-Testing	Post-Testing	Average Change
Sparta Jump Height (cm)	31.95 ±9.27	34.06 ±9.55	2.11**
ECC Impulse (Ns/kg)	0.71 ±0.17	0.75 ±0.18	0.04
CON Impulse (Ns/kg)	2.40 ±0.36	2.47 ±0.36	0.07**
Max Velocity (m/s)	2.64 ±0.35	2.70 ±0.35	0.06**
Max Power (W/kg)	23.71 ±7.02	24.62 ±6.52	0.91*
CM Depth (m)	0.42 ±0.08	0.44 ±0.08	0.02**
mRSI (m/s)	0.33 ±0.11	0.33 ±0.11	0.00
Load (N/s)	2,968.68 ±1,647.58	2,989.54 ±1,916.67	20.86
Explode (N/kg)	16.15 ±1.50	16.04 ±1.51	-0.11
Drive (Ns/kg)	6.20 ±0.51	6.45 ±0.56	0.25**
Injury Risk	2.35 ±1.17	2.94 ±1.29	0.59**
Sparta Score	78.90 ±4.99	78.71 ±5.39	-0.19
ForceDecks Jump Height (cm)	32.99 ±8.91	30.22 ±7.51	-2.77**

* Indicates statistical significance ($p \leq 0.05$)

** Indicates statistical significance ($p \leq 0.01$)

ECC=eccentric, CON=concentric, CM=countermovement, mRSI=modified reactive strength index

3.2. Performance Testing

Lower body wingate anaerobic capacity improved as evidenced by average relative power (W/kg) (p=0.022) and absolute power (W) (p=0.045) significant increase from pre- to post-testing (Table 3). However, there was no significant change in IMTP or standing long jump performance with training.

Table 3. *Pre- and Post-Testing Performance Data.*

Variable	Pre-Testing	Post-Testing	Average Change
LB Wingate PP (W)	686.93 ±230.93	709.55 ±222.64	22.62
LB Wingate PP (W/kg)	7.80 ±1.84	8.08 ±1.60	0.28
LB Wingate AP (W)	490.56 ±148.19	510.35 ±148.31	19.79*
LB Wingate AP (W/kg)	5.60 ±1.16	5.85 ±1.07	0.25*
Standing Long Jump (m)	1.93 ±4.07	1.96 ±3.54	0.03
IMTP Peak Vertical Force (N)	2,625.67 ±622.57	2,670.96 ±627.13	45.29

* Indicates statistical significance ($p \leq 0.05$)

LB=Lower Body, PP= Peak Power, AP=Average Power, IMTP=Isometric Mid-Thigh Pull

3.3. Classification

The participants were distributed in various Sparta Movement Signature "buckets" before training started based on Sparta classifications. These classifications are based on the individuals' lowest performance metric(s). Table 4 below displays the pre-testing movement focus, the post-test movement focus, and how many participants in each pre-test bucket moved to each post-test bucket. load & explode was the most common movement focus in both pre- and post-testing, followed by explode. There were zero subjects in the drive and load & drive groups and very few (3) in the load group. Only 8 of 31 subjects, or 25.8%, experienced a change in movement focus following 10 weeks of specific training incorporating Sparta Science recommendations.

Table 4. *Changes in Movement Focus.*

Movement Focus		Load & Explode	Explode	Drive	Load & Drive	Load	Total
Pre-Test Total		16	12	0	0	3	31
Effect of Training on Jump Classification	No Change	13	10	0	0	0	23
	To Load & Explode	--	2	0	0	3	5
	To Explode	2	--	0	0	0	2
	To Drive	0	0	--	0	0	0
	To Load & Drive	0	0	0	--	0	0
	To Load	1	0	0	0	--	1
Post Test Total		18	12	0	0	1	31

3.4. Responders vs. Non-Responders

The participants in the study were divided based on their jump height change measured by Sparta over the 10 weeks of training. The responders (n=16), were those who were in the top 50th percentile for jump height change, and non-responders (n=15), those who were in the bottom 50th percentile (Table 5). Responders had an average increased jump height of 4.01 centimeters (p = 0.000) on the Sparta plate and had significant increases in concentric impulse (+0.07 N s/kg), max velocity (+0.06 m/s), and max power (+0.91 W/kg) at the post-testing timepoint. They demonstrated no difference in the Sparta performance metrics (load, explode, and drive), Sparta score, or injury risk. However, they did increase their standing long jump distance by 0.08 meters on average. Four of the Responders shifted their movement signature (one from explode to load & explode, two from load & explode to explode, and one from load & explode to load). ForceDecks jump height for responders decreased and average of 2.64 cm.

The Non-Responder group had an average jump height increase of only 0.08 centimeters on the Sparta plate. The only significant change in their CMJ mechanics was an increase in the Sparta explode measure (p=0.008), and there was no change in their standing long jump performance from pre- to post-testing (Table 6). However, four non-responders changed their jump classification (three from load to load & explode and one from explode to load & explode). In addition, non-responders ForceDecks jump height decreased an average of 2.92 cm.

Table 5. *Significant Differences Between Pre- and Post-Testing for Responders and Non-Responders for Jump Testing.*

	Responders			Non-Responders		
Variable	Pre-Testing	Post-Testing	Average Change	Pre-Testing	Post-Testing	Average Change
Sparta Jump Height (cm)	31.39 ±9.04	35.40 ±9.09	4.01*	32.58 ±9.77	32.66 ±10.13	0.08

	Responders			Non-Responders		
Variable	Pre-Testing	Post-Testing	Average Change	Pre-Testing	Post-Testing	Average Change
CON Impulse (Ns/kg)	2.39 ±0.35	2.52 ±0.30	0.13*	2.41 ±0.40	2.41 ±0.42	0.00
Max Velocity (m/s)	2.63 ±0.33	2.74 ±0.30	0.11*	2.65 ±0.38	2.65 ±0.40	0.00
Max Power (W/kg)	22.88 ±6.08	24.73 ±5.45	1.85*	24.59 ±8.03	24.51 ±7.69	-0.08
CM Depth (m)	0.43 ±0.08	0.46 ±0.08	0.03	0.42 ±0.08	0.43 ±0.07	0.01
mRSI (m/s)	0.31 ±0.10	0.33 ±0.09	0.02	0.34 ±0.12	0.33 ±0.13	-0.01
Explode (N/kg)	16.07 ±1.23	16.26 ±1.23	0.19	16.23 ±1.78	15.81 ±1.78	-0.42*
Load (N/s)	2,948.76 ± 1,1617.73	3,005.15 ±1,964.41	56.39	2,989.92 ± 1,735.48	2,972.89 ± 1,933.13	-17.03
Drive (N*s/kg)	6.16 ±0.38	6.39 ±0.39	0.23	6.24 ±0.62	6.52 ±0.71	0.28
Injury Risk	2.06 ±0.93	2.69 ±1.20	0.63	2.67 ±1.35	3.20 ±1.37	0.53
Sparta Score	78.81 ±4.28	79.31 ±4.19	0.50	79.00 ±5.81	78.07 ±6.52	-0.93
ForceDecks Jump Height (cm)	33.93 ±8.99	31.29 ±6.31	-2.64	32.00 ±9.04	29.08 ±8.63	-2.92

Note: *Indicate statistical significance ($p \leq 0.05$)

CON=concentric, CM=countermovement, mRSI=modified reactive strength index

When examining differences between responders and non-responders, both groups experienced a change in movement signature of 4 participants (non-responders: 4/15; responders: 4/16). As for the performance metrics, only standing long jump yielded a significant difference post-training.

Table 6. *Significant Differences Between Pre- and Post-Testing for Responders and Non-Responders for Performance Metrics.*

	Responders			Non-Responders		
Variable	Pre-Testing	Post-Testing	Average Change	Pre-Testing	Post-Testing	Average Change
LB Wingate PP (W)	654.55 ±238.67	673.79 ±214.31	19.24	721.47 ±225.32	747.90 ±232.29	26.43
LB Wingate PP (W/kg)	7.74 ±1.66	8.01 ±1.18	0.27	7.86 ±2.07	8.15 ±1.99	0.29
LB Wingate AP (W)	480.12 ±163.32	492.63 ±144.58	12.51	501.70 ±134.98	529.24 ±154.91	27.54
LB Wingate AP (W/kg)	5.70 ±1.09	5.89 ±0.84	0.19	5.49 ±1.25	5.80 ±1.31	0.31
Standing Long Jump (m)	1.90 ±0.37	1.98 ±0.35	0.08*	1.96 ±0.44	1.94 ±0.36	-0.02
IMTP Peak Vertical Force (N)	2,565.83 ±705.69	2,641.32 ±743.94	75.49	2,689.50 ± 537.15	2,702.58 ±497.72	13.08

Note: * Indicates statistical significance ($p \leq 0.05$)

LB=Lower Body, PP=Peak Power, AP=Average Power, IMTP=Isometric Mid-Thigh Pull

4. Discussion

This study showed little to no changes in countermovement vertical jump performance among participants, despite administering training programs which targeted increased vertical jump performance. When examining the participant pool in entirety, there were significant changes in the Sparta-derived measures drive and Sparta Injury risk. Interestingly, there were no participants assigned to any drive-related group (drive, drive & load, drive & explode) at the pre- or post-testing time points. All participants mixed amongst the load, explode, and load & explode groups. In addition, there were no significant changes in Sparta Score following training.

The changes in jump height between the Sparta and ForceDecks plates for the entire participant pool were interesting. The Sparta jump height increased 2.11 centimeters on average, while ForceDecks jump height decreased by 2.77 centimeters. Both systems use flight time to calculate jump height, and the test order was randomized to mitigate fatigue effects. Previous research has reported that Sparta Science overestimates jump height when compared to other systems, such as ForceDecks [19]. Still, we are uncertain why one force plate system demonstrated a net improvement in jump score while the other yielded a net decrease. However, it is important to note that Sparta utilizes a single plate system and ForceDecks utilizes a dual plate system; this could have affected the differences in the results.

Previous research that investigated a 5-week training program comparing an experimental group with a Sparta prescribed training program and a control group with a traditional training program reported all participants experienced similar performance results [1]. Our study found the same. When examining the CMJ mechanics that influence jump height, such as concentric impulse and countermovement depth [20-22], there were small but significant increases from pre- to post-testing. These slight changes to jump mechanics could explain the increase in jump height. In addition, the Sparta metric “Drive,” which is concentric relative impulse, also significantly increased. These two metrics could help explain why participants may have experienced an increase in jump height during post-testing.

The Sparta “Injury Risk” variable also significantly increased from pre- to post-testing. While an increased risk of injury sounds concerning, there is skepticism regarding how different systems quantify this risk. A recent study by Hando, et. al. [23] concluded that Sparta scores were not effective predictors of increased MSKI risk within Air Force Special Warfare trainees. Similarly, Marine officer school candidates’ injury incidence during a 10-week military training did not differ in the way that Sparta injury risk scores predicted [24]. Indeed, the subgroup with highest MSKI incidence was identified as being at lowest risk based on Sparta injury-risk algorithm [24]. Sparta states their injury risk is based on the magnitude of differences between their three jump variables -- load, explode, and drive [25]. However, injury risk is most often related to inter-limb asymmetry that can be found in jump mechanics [26, 27]. Previous research investigating asymmetry levels in male and female athletes reported that stronger athletes are less likely to experience a large amount of inter-limb asymmetry [17]. It is also known that a decreased amount of inter-limb asymmetry reduces injury risk [27]. However, Sparta is a single force plate design, as opposed to the commonly used dual plate design, so inter-limb asymmetry cannot be quantified with this platform. If stronger individuals are consistently less likely to experience injuries, perhaps there is an increased need for the training program to focus on strength improvements rather than specific jump variables.

The lack of change in movement focus and Sparta score was unexpected. Sparta provides exercise suggestions to improve vertical jump metrics by targeting an individual’s weakest jump phase, with a goal to improve overall. Based on the results of this study, only 8 subjects changed movement focus was observed. The only Sparta-derived variable with a significant positive change was drive, which was expected with the increase in concentric impulse. However, this increase in drive did not affect the jump classification of any participant since no one was initially in the drive classification category.

When looking at the performance metrics for the entire participant pool, only lower body wingate average power (relative and absolute) significantly increased from pre- to post-testing. This suggests that the training program primarily increased an individual’s ability to maintain high power output throughout a maximum effort test. While beneficial, the result was not expected. To achieve more well-rounded performance at post-testing, we recommend a training program that emphasizes whole body strength and force development.

When the participant pool was partitioned into responders and non-responders, the results were interesting. The responders saw significant, albeit small effect size, increases in Sparta jump height, concentric impulse, max velocity, and max power. It is not surprising these metrics were significantly higher because this group had the greatest increase in jump height. As mentioned before, concentric impulse as well as max velocity play an important role in jump height. The responders not only increased their vertical jump height, but they also improved their standing long jump distance as well. This could lead the us to believe that perhaps the responders group experienced greater strength and force production changes compared to the non-responders. Interestingly, the responders did not experience a significant change in any Sparta-derived jump metrics, but the non-responders did. The non-responders had a statistically significant decrease in explode (-0.42 N/kg), but this change in the explode measure did not translate to any other significant change in jump performance.

This study exhibited both strengths and weakness. This study is unique in its exploration of jump performance alongside other performance tests, which allowed us to directly compare the training effects on a series of different performance tasks. In addition, the study cohort completed a 10-week, concurrent training program that was highly standardized across participants with both high intensity interval training (HIIT) and cardio. However, this work could have benefited from a crossover design that would allow researchers to more directly compare the effects of the Sparta training recommendations to a program focused on strength, force, and power development. Further research on this topic should be made, specifically in populations outside of military personnel, as well as further investigation into asymmetry and injury risk.

5. Conclusions

The Sparta recommendations had minimal impact on jump performance after 10 weeks of training. There were small increases in jump height and propulsive mechanics as well as Sparta's Injury Risk prediction variable. While the increased injury risk value is concerning, there is no consensus on the correlation between Sparta injury risk and injury rate. It is important to focus on the needs and demands of the individuals to make training choices that will yield optimal results. The results of this study indicated that practitioners are not likely to achieve optimal results for either injury risk or jump performance by following Sparta's training suggestions. Instead, these results indicate that the appropriate training program recommendations include focus on the specific needs of an individual, to include strength, power, and force-developing exercises to elicit optimal jump and performance metric outcomes.

Abbreviations

CMJ	Countermovement Jump
HP	Human Performance
MSKI	Musculoskeletal Injuries
AFRL	Air Force Research Laboratory
IMTP	Isometric Mid-thigh Pull
HIIT	High Intensity Interval Training
RDL	Romanian Deadlift
ECC	Eccentric
CON	Concentric
mRSI	Modified Reactive Strength Index
LB	Lower Body
PP	Peak Power
AP	Average Power

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Data Availability Statement

The data supporting the outcome of this research work has been reported in this manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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