Navy PRT Modality Validation Pilot Study

NAVAL HEALTH RESEARCH CENTER

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EXECUTIVE SUMMARY

Background/Objective

The U.S. Navy is transitioning from a culture of fitness testing to a more pervasive culture of overall fitness. The objective is to shift away from the current Physical Fitness Assessment, which evaluates general physical fitness levels and disease risk, and move toward more realistic measures of performance fitness and mission readiness. To that end, the Physical Readiness Program has been charged with developing an alternative Physical Readiness Test (PRT) that will assess operationally relevant fitness components, such as speed, agility, power, anaerobic capacity, aerobic endurance, and muscular strength and endurance. The goal of this pilot study was to evaluate and down-select from 11 to 3–5 fitness modalities for potential inclusion in an alternative PRT.

Methods

Forty-one active duty sailors (30 males; 11 females) completed traditional strength tests and 11 performance fitness modalities consisting of upper/lower body strength and power events, total body strength events, timed sprints/runs, and a core strength task. Modality down-selection was based on scalability, physical space and equipment requirements, safety, time and cost to administer, and correlations of sailors' individual performance on the new modalities with both their performance on traditional strength tests and their most recent PRT scores (curl-ups, push-ups, 1.5-mi run).

Results

There were strong correlations ($r > 0.7$) for upper body strength events between 1 repetition maximum (1RM) bench press and both seated medicine ball throw and overhead weighted lift. Other strong correlations for upper body endurance were between push-ups and both pull-ups and flexed arm hang. Strong correlations were also noted between the 1.5-mi run and both repeated 300-yd shuttle run and 800-m sprint. Only moderate correlations ($0.5 < r < 0.7$) existed between lower body events (standing long jump, vertical jump) and 1RM seated leg press and 1.5.-mi run. No significant relationship was determined within the core strength events nor total body strength modalities. The seated medicine ball throw, the only modality that measured upper body strength and power, had a strong correlation with 1RM bench press ($r = 0.79$). The standing long jump evaluated lower body strength and power while encompassing a balance and coordination component. The repeated 300-yd shuttle run assessed agility and aerobic/anaerobic capacity and was highly correlated ($r = 0.82$) with participants' 1.5-mi run times on their most recent PRT. Lastly, the forearm plank measured both core muscular strength and endurance.

Conclusions

The seated medicine ball throw, standing long jump, repeated 300-yd shuttle run, and forearm plank were the modalities recommended for inclusion in an alternative PRT. These new modalities evaluate more operationally relevant measures of performance fitness, thereby providing a more comprehensive assessment of a sailor's mission readiness. However, before an alternative PRT can be launched, these modalities would need to be validated in a follow-on large-scale study in order to develop the appropriate norms and performance standards across gender and age brackets.

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INTRODUCTION

The U.S. Navy recently revised its Physical Readiness Program (PRP) in an effort to transition from a primary focus on fitness testing toward a more pervasive culture of fitness. This new approach was developed to strike a better balance between health and physical readiness and to preserve a resilient workforce that is ready to fight. The long-term goal is to move away from the Physical Fitness Assessment (PFA), which assesses general physical fitness levels and disease risk, toward more realistic measures of health, fitness, and mission readiness. To that end, the PRP has been charged with developing an alternative Physical Readiness Test (PRT) that will assess performance fitness components, such as speed, agility, power, anaerobic capacity, muscular strength, balance, coordination, and reaction time. The 11 modalities selected for testing were identified by a physical readiness working group and are currently used by industry fitness experts to measure parameters of athletic performance. These modalities included upper body tasks (seated medicine ball throw, overhead weighted lift, pull-ups/flexed arm hang), lower body tasks (standing long jump, vertical jump), total body tasks (dummy drag, loaded carry), timed runs/sprint (60-yd shuttle, repeated 300-yd shuttle, 800-m sprint), and a core strength and endurance task (forearm plank).

Traditionally, Naval Health Research Center (NHRC) has been a key player in developing and validating the Body Composition Assessment and PRT standards that are used in the current PFA (Buono, 1987; Hodgdon et al., 2007; Parker et al., 2006). Thus, NHRC was tasked with conducting a small-scale, low-impact pilot evaluation of these 11 potential fitness tasks and has recommended the best 4 fitness modalities for future validation and/or inclusion in an alternative PRT. The overarching goal of creating a new performance-based PRT is to enhance the accuracy of assessing sailors' fitness levels and operational readiness and to provide operational commanders with advanced knowledge of the physical capabilities and/or limitations of personnel.

METHODS

Participants

Letters of support were obtained from Pacific Fleet and Commander, Navy Installations Command Hawaii, to conduct this pilot study on Joint Base Pearl Harbor-Hickam (JBPHH) with active duty sailors stationed for shore duty. Recruitment flyers were posted in local gyms and email announcements were sent out to various commands located on board JBPHH. All sailors who were interested in participating in the study were briefed on the study within a classroom in groups of their peers (either junior enlisted or senior enlisted and officers). Following the dissemination of information on the study by the principal investigator, sailors were given the opportunity to ask questions and volunteer to participate in the study. Sailors volunteering to participate in the study underwent the informed consent process and were screened for eligibility. Sailors were considered eligible to participate if they were between the ages of 18 to 59 years, had scored an overall “good” or better on their last two PRTs, were cleared for full duty, had a current Periodic Health Assessment, and a medically cleared Physical Activity Risk Factor Questionnaire (PARFQ). Sailors were considered ineligible from study participation if they had any musculoskeletal injury or were currently ill, were on limited duty status, and/or were over the age of 59 years. Any female sailors who were pregnant were excluded from the study; pregnancy status was confirmed during the screening process by completing a PARFQ. Sailors were not compensated for their participation in the study.

Procedures

General Approach

Participants reported to the testing site (JBPHH Fitness Center) in their Navy physical training uniform on 3 nonconsecutive testing days during either a morning or afternoon 4-hr time block over a 1-week period. Prior to exercising on each testing day, consented participants were asked the Navy’s pre-physical activity questions that are routinely asked prior to participation in unit physical training or prior to beginning a PRT, per OPNAVINST 6110.1J.

Participants who did not satisfy all the pre-physical activity questions were excused and excluded from further participation in the study. Eligible participants were led through a series of dynamic warm-up exercises (bent-over Ys; chest press/shoulder press; basic squats; glute bridge with knee extension; three side steps touch the deck; jumping jacks; quick feet/high knees) prior to data collection. The first testing day (Day 1) comprised upper, lower, and core body muscular strength tests (handgrip strength, 1 repetition maximum [1RM] lifts, and forearm plank). The subsequent testing days (Days 2 and 3) included the 10 proposed fitness modalities, which were divided between 2 days with at least 24 hr between testing sessions. Metrics from these traditional strength tests were correlated to values obtained from each of the 11 fitness modalities.

Each testing day was composed of 4–5 fitness events that were strategically organized to minimize muscular fatigue of a particular muscular group/energy system while still maximizing individual performance. Although the timing between events and between individual efforts on the same fitness modality was not recorded, participants were given sufficient recovery time. The study testing schedule was executed as follows:

Day 1
Participant height and weight measurement
Forearm plank
Handgrip strength test
Bench press (1RM)
Seated leg press (1RM)

Day 2
Repeated 300-yd shuttle run
Loaded carry
Seated medicine ball throw
Pull-ups (males)/flexed arm hang (females)
Standing long jump

Day 3
60-yd shuttle run
Overhead weighted lift
Vertical jump
Dummy drag
800-m sprint

Table 1. Fitness Modalities and Corresponding Fitness Component Measured

Event category	Modality	Fitness component tested
Upper body	Seated medicine ball throw	Upper body strength and power
	Overhead weighted lift	Upper body strength and endurance
	Pull-ups (males)/flexed arm hang (females)	Upper body strength and endurance
Lower body	Standing long jump	Lower body strength, power, balance, coordination
	Vertical jump	Lower body strength and power
Total body	Dummy drag	Total body strength
	Loaded carry	Total body strength, agility, balance, coordination
Timed sprints/runs	60-yd shuttle run	Speed, agility, balance, coordination
	Repeated 300-yd shuttle run	Anaerobic capacity, agility
	800-m sprint	Aerobic and anaerobic capacity
Core event	Forearm plank	Core strength and endurance

Strength Testing Procedures: Day 1

Forearm Plank: The forearm plank was proposed to assess core muscular endurance. Each participant held a basic plank position (maintaining a straight, strong line from the head to the toes with an extended leg position, keeping the head and spine in a neutral position) as a prone bridge supported by the forearms and feet for as long as possible, or up to 300 s (Figure 1). Participants were instructed to lie face down on the ground. Participants placed their elbows and forearms under their chest, vertically below the shoulders, with forearms and fingers extending straight forward, and propped themselves up into a plank position using their toes and forearms for support. Feet were placed hip-width apart, with the ankles at 90 degrees and knees straight, pelvis tilted into a neutral position, and back flat. Only the forearms and toes were in contact with the ground. The neck was kept neutral throughout the duration of the test so that the body remained straight from the head to the heels. Forearms were angled in, but the hands could not be clasped together. Participants were permitted to maintain eye contact with their hands to help maintain a neutral spine, and a straight line from head to ankles. Participants were instructed to hold the plank position as long as possible, or were instructed to end the test once a maximum time of 300 s was achieved. Timing began when the participant was in the proper position and indicated they were ready to begin, and final time was recorded when form was broken. No breaks were allowed and any break in form resulted in ending the test. Research personnel ensured proper plank position was held and called out the time at 30-s increments to the participant. When a flat back or proper neck alignment could not be maintained despite verbal cueing from the investigator, the test was terminated.

Figure 1. Study participants executing the forearm plank. (Photo courtesy of NHRC)

Handgrip Strength Test: Handgrip strength was measured as a generally accepted predictor of total muscular strength. Study personnel adjusted a hand dynamometer to the appropriate size of the participant's hand. The participant grasped the dynamometer between the fingers and the palm at the base of the thumb of the dominant hand. The participant held the dynamometer in line with the forearm at thigh level so that it was not touching the body (Figure 2). The participant stood with the feet hip-width apart with toes pointing forward. Study personnel informed the participant that neither the hand nor dynamometer should touch the body or any other object during the test. Research personnel instructed the participant not to hold their breath. The participant took a breath in before starting the squeeze, then blew out the air during the squeeze. The participant was instructed to emphasize the quickness and hardness of the squeezing motion (with fist slightly shaking). The participant conducted one practice submaximal force squeeze to demonstrate proper form and procedure followed by three maximal efforts. Participants were given sufficient rest between each effort. The best of three efforts was recorded as the final score.

Photo courtesy of NHRC

Figure 2. Participants performing the handgrip strength test to assess total body strength.

1RM Strength Tests: The participant completed a 1RM weight test to assess muscle strength. The 1RM has been shown to be a safe testing method in a variety of populations with varied strength training histories, ranging from collegiate athletes (Parchmann & McBride, 2011), to cardiac patients (Barnard, Adams, Swank, Mann, & Denny, 1999), to elderly adults with no prior strength training experience (Shaw, McCully, & Posner, 1995).

In this study, a 1RM test was completed for two movements: the bench press to assess upper body strength and the seated leg press to evaluate lower body strength (Figure 3). The participant practiced the movements with little to no added weight on the barbell and/or leg press to ensure proper form and warm up the muscles. Subsequently, they performed a number of repetitions, with incremental weight increases and a sufficient rest period in between cycles. Initial weight selection for the warm-up weight for the bench press and seated leg press (5–10 repetitions) for a participant experienced in weight lifting was self-selected based on prior resistance training. An inexperience participant had an initial warm-up weight selected by research personnel corresponding to 50% of the participant's body weight (Bianco, Filingeri, Paoli, & Palma, 2015). Cycles were repeated until the participant reached a weight that could not be lifted. The participant was guided first through the chest press, and then through the seated leg press. Since different muscle groups were targeted with these two movements, the participant's performance on the second movement was not adversely affected. To ensure participant safety, trained spotters were present in the event that assistance was needed.

General 1RM Testing Protocol

1. Instructed the participant to warm up with a light resistance that easily allowed 5–10 repetitions.
2. Provided a rest period.
3. Estimated a warm-up load that would allow the participant to complete 3–5 repetitions by adding:
   - 10–20 lb (4–9 kg) or 5–10% for upper body exercise, or
   - 30–40 lb (14–18 kg) or 10–20% for lower body exercise.
4. Provided a rest period.
5. Estimated a conservative, near-maximum load that would allow the participant to complete 2–3 repetitions by adding:
   - 10–20 lb (4–9 kg) or 5–10% for upper body, or
   - 30–40 lb (14–18 kg) or 10–20% for lower body exercise.
6. Provided a rest period.
7. Made a load increase:
   - 10–20 lb (4–9 kg) or 5–10% for upper body exercise, or
   - 30–40 lb (14–18 kg) or 10–20% for lower body exercise.
8. Instructed the participant to attempt a 1RM.
9. If the participant was successful, provided a rest period and went back to step 7.
   If the participant failed, provided a rest period, then decreased the load by subtracting:
   - 5–10 lb (2–4 kg) or 2.5–5% for upper body exercise, or
   - 15–20 lb(7–9 kg) or 5–10% for lower body exercise.

   AND then went back to step 8.

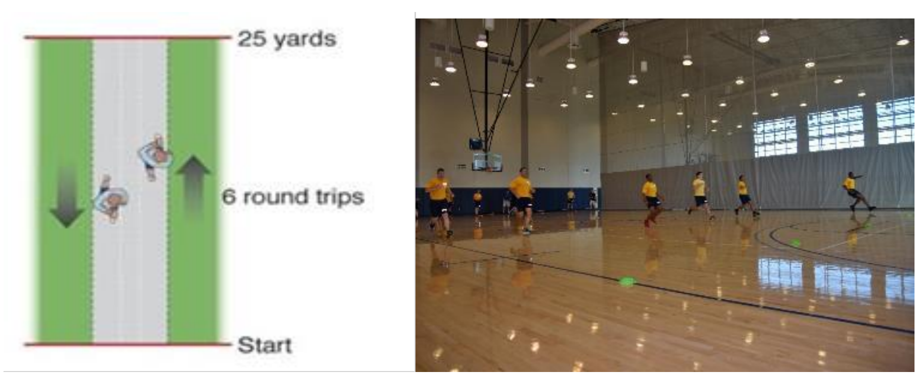
The load was steadily increased or decreased until the participant could complete 1RM with proper exercise technique. Ideally, the participant's 1RM was measured within 3–5 testing sets.

Photo courtesy of NHRC

Figure 3. Participants performing the 1RM bench press (left) and 1RM seated leg press (right) to measure upper and lower body strength.

Potential PRT Modality Testing Procedures: Day 2

Repeated 300-yd Shuttle Run (score is average of two bouts): The repeated 300-yd shuttle run was proposed to assess individual aerobic/anaerobic capacity and agility. This timed event was conducted indoors. within JBPHH Fitness Center's basketball courts. Study personnel ensured marker cones and lines were placed 25 yd apart to indicate the accurate sprint distance. Participants started with a foot on the start line. When instructed by the timer, participants ran to the opposite 25-yd line, touched it with their foot, turned, and ran back to the start. This was repeated six times without stopping (covering 300 yd total; Figure 4). After a 5-min rest, the test was repeated. Study personnel recorded the average of the two 300-yd shuttle run times. This was a maximum-effort anaerobic test, and in order to receive the highest score, participants were instructed to sprint at 100% effort the entire time. Participants were encouraged not to pace themselves; the best score was achieved by exerting maximum effort from the start.



Adapted, by permission, from Gilliam, 1983. Photo courtesy of NHRC

Figure 4. The repeated 300-yd shuttle run course setup and simulated participant movement (left). Participants executing the repeated 300-yd shuttle run (right).

Loaded Carry: The loaded carry was proposed to assess total body strength, agility, balance, and coordination. This was a timed event conducted outdoors on a flat grass-covered field. This event involved a set of dumbbells (males = 60 lb, each hand; females = 40 lb, each hand) and a modified Illinois Agility Test course (Figure 5). When instructed to start, the participant walked while carrying the dumbbells at their sides and maneuvered through the 105-yd agility test course. Running was not permitted and doing so resulted in a failure of the event. The participant was permitted to lower and release the dumbbells to the ground in a controlled manner to adjust grip at any time; however, the clock continued to run. The time to complete the entire course was recorded in seconds for each participant.

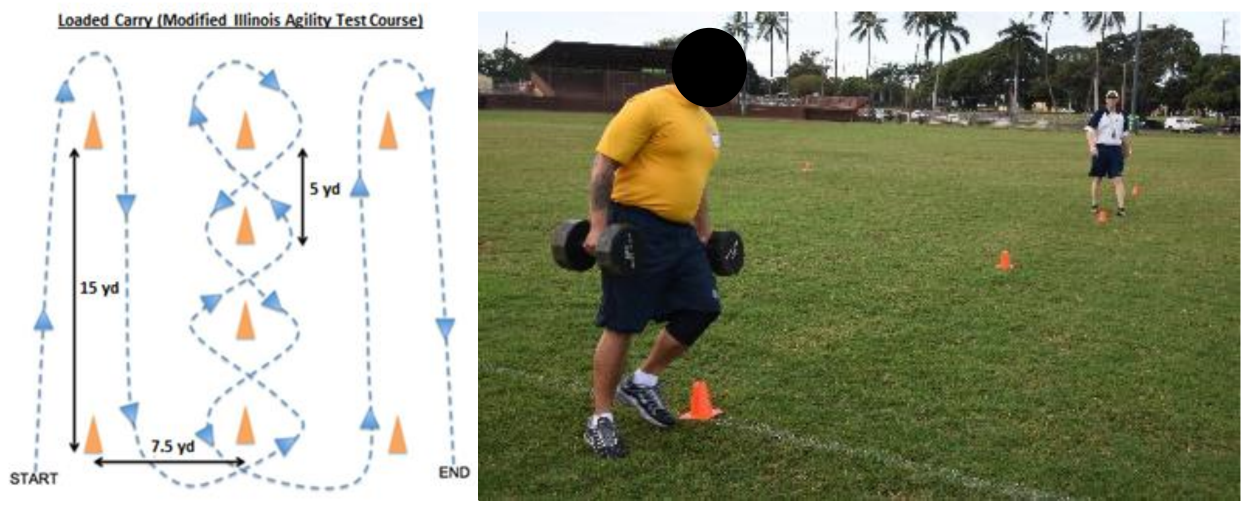


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Photo courtesy of NHRC

Figure 5. The loaded carry course setup (orange cones) and simulated participant movement (blue dotted line with blue arrows–left). Participant performing loaded carry with 120 lb (right).

Seated Medicine Ball Throw: The seated medicine ball throw was proposed to assess upper body strength and power. This was not a timed event and was conducted indoors. Using a 2 kg (4.4 lb) medicine ball, the participant sat on the floor with their lower back against a yoga block and upper back against the wall. The participant's legs were extended straight out in front on the floor and the head was not permitted to touch the wall. The participant held the medicine ball with both hands and when instructed, brought the medicine ball to the chest with elbows comfortably at their sides. After a brief pause in this position, the participant pushed/threw the medicine ball upward and outward at a 45° angle (Figure 6). To maximize the distance of the throw, the participant followed through by flexing the wrists. Participants were not permitted to throw the medicine ball like shooting a basketball or throwing a baseball. The distance of the throw was measured from the wall to the spot the ball contacted the floor. The participant was offered two practice throws. After the practice throws, the participant performed three maximum effort throws for measurement. The farthest measurement was kept for scoring. Throws in which the participant failed to maintain contact with the wall or threw incorrectly did not count. The throw was scored from the wall to the nearest 10 cm from where the ball contacted the floor.

Photo courtesy of NHRC

Figure 6. Participant performing the seated medicine ball throw to assess upper body strength and power.

Pull-Ups (males)/Flexed Arm Hang (females)

Pull-ups (males): Pull-ups were proposed to assess upper body muscular endurance in males. This was not a timed event and was conducted indoors. The permitted bar diameter was between 1 and 1.75 inches. Using athletic tape on the bar was authorized. The bar was high enough to allow the tallest participant's legs to hang straight without touching the floor when the arms were fully extended. Any sweatshirt/running suit top/long-sleeved shirt was removed during the pull-up event in order to observe the lockout of the elbows with each repetition. The preparatory command was "Ready" and the execute command was "Go." Assistance to the bar with a step up, being lifted up, or jumping up was authorized. Assistance up to the bar was not used as momentum into the first pull-up. The bar was grasped with both palms facing either forward or to the rear. The correct starting position began when arms were fully extended beneath the bar, feet were free from touching the ground or any bar-mounting assist, and the body was motionless. Legs could be positioned in a straight or bent position, but knees were not to be raised above the waist. One repetition consisted of raising the body with the arms until the chin was above the bar and then lowering the body until the arms were fully extended; this motion was repeated as many times as possible (Figure 7). At no time during the execution of this event could the participant rest the chin on the bar. The intent was to execute a vertical "dead hang" pull-up. A certain amount of inherent body movement was permitted to occur as the pull-up was executed. However, the intent was to avoid a pendulum-like motion that enhanced the ability to execute the pull-up. Whipping, kicking, or kipping of the body or legs, or any leg movement used to assist in the vertical progression of the pull-up was not authorized. If observed, the repetition did not count for score. The goal of this event was for the participant to complete as many pull-ups as possible.

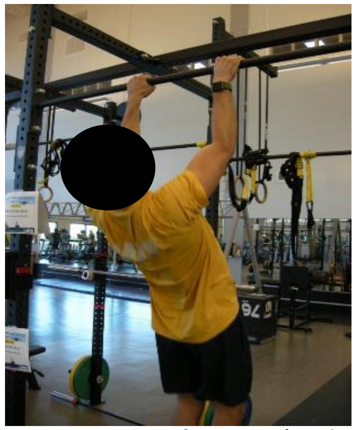

Photo courtesy of NHRC

Figure 7. The pull-up (males only) setup.

Flexed Arm Hang (females): The flexed arm hang was proposed to assess upper body muscular endurance in females. This timed event was conducted indoors. Sweatshirts were removed while performing the flexed arm hang event in order to observe when the participant had completely locked out the elbows. Assistance to the bar with a step up, being lifted up, or jumping up to the start position was authorized. The bar was grasped with both palms facing either forward or to the rear. The preparatory command was “Ready” and the execute command was “Go.” The correct starting position began when the participant’s arms were flexed at the elbow, the chin was held above the bar and not touching it, and the body was motionless. At no time during the execution of this event could a participant rest her chin on the bar. The participant was allowed to drop down below the bar; however, some degree of elbow flexion had to be maintained with both arms. Once a participant’s arms were fully extended or the participant dropped off the bar, the clock was stopped. The goal of this event was for the participant to hang (maintain elbow flexion) for as long as possible within the prescribed time limit of 70 s. Seventy seconds was considered the maximum score; however, if the participant reached the 70-s threshold, they were permitted to continue to hang as long as they could maintain proper form.

Standing Long Jump: The standing long jump was proposed to assess lower body power/strength, balance, and coordination. This was not a timed event and was conducted indoors. The participant stood behind the takeoff line with feet parallel and shoulder-width apart. The participant was instructed to jump as far as possible with a two-foot take-off and landing. The participant could rock on toes and heels, but feet could not be raised off the floor before the jump. The jump began by moving both arms forward and backward (arm counter movements) while bending at the knees and hips. The participant could not move the feet after landing. If feet moved either forward or backward after the jump, it was not scored and did not count. The participant could perform two submaximal practice jumps for form only, followed by three maximum effort jumps (Figure 8). The jump was scored to the closest centimeter from the heel closest to the takeoff line. Only the longest measured jump was scored.

Photo courtesy of NHRC

Figure 8. Participants performing the standing long jump procedure.

Potential PRT Modality Testing Procedures: Day 3

60-yd Shuttle Run: The 60-yd shuttle run was proposed to assess speed, agility, balance, and coordination. Four marker cones were placed at the 0-, 5-, 10-, and 15-yd lines. The participant started from one end, ran 5 yd and then back to the start, ran 10 yd and then back to the start, ran 15 yd and then finished at the start line. A total of 60 yd was completed (Figure 9). The participant was required to touch the line with their hand at each turn except at the finish line, for a total of five touches. The time to complete the test in seconds was recorded. The score was recorded as the best time of three trials. Participants were given sufficient rest between the three efforts.

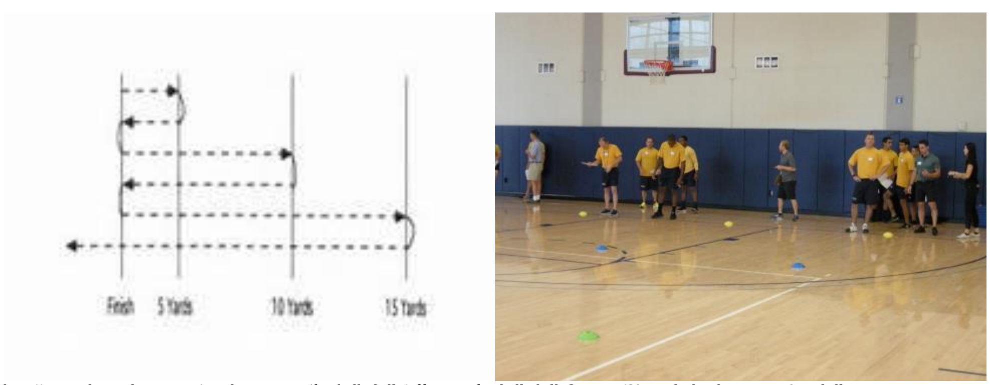

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Figure 9. The 60-yd shuttle run course setup and simulated sailor movement (black dotted line with arrows–left). Participants waiting to begin the 60-yd shuttle run (right; photo courtesy of NHRC).

Overhead Weighted Lift: The overhead weighted lift was proposed to evaluate upper body muscular endurance. This was a 2-min timed indoor event. The preparatory command was “Ready” and the execute command was “Go.” The overhead weighted lift is a repetitive lift of a 30-lb dumbbell from shoulder height to overhead. Prior to the start of the overhead weighted lift, participants were paired up. The partner counting repetitions was located to the side (at an approximately 90-degree angle; Figure 10) of the participant performing the overhead weighted lift in order to observe elbow lockout and prevent injury should the participant drop or return the dumbbell to the deck.

Starting position for the overhead weighted lift was holding the dumbbell sideways at shoulder height with both hands. Proper lifting technique was head up, chest elevated, and lumbar curve maintained. Feet were shoulder-width apart or staggered in a basic warrior stance position. The dumbbell was lifted to a point overhead where the elbows were momentarily locked out. The dumbbell did not have to be lifted directly overhead. Once lockout was achieved, the dumbbell was lowered to a point where the top of the dumbbell was at or below chin level; this counted as one repetition. When held in the starting position, the top of the dumbbell was to remain parallel to the deck throughout the entire movement. This ensured participant safety and that the weighted lift was an overhead lifting motion rather than an angled pressing motion. Participants were encouraged to use their legs to generate upward momentum of the dumbbell, especially when fatigued. There was no penalty if participants chose not to use their legs. Alteration of stance during the overhead weighted lift was permissible. Participants were authorized to rest during the overhead weighted lift testing. Holding the dumbbell in the starting position or placing it on the deck was allowed. If placed on the deck, the dumbbell was to be lowered in a controlled movement and not thrown or dropped. Once lowered to the deck, no assistance was provided when returning the dumbbell to the starting position.

Study personnel monitored the event and ensured proper technique and repetition counting were conducted. The goal of this event was for participants to complete as many overhead weighted lift repetitions as possible within 2 min.

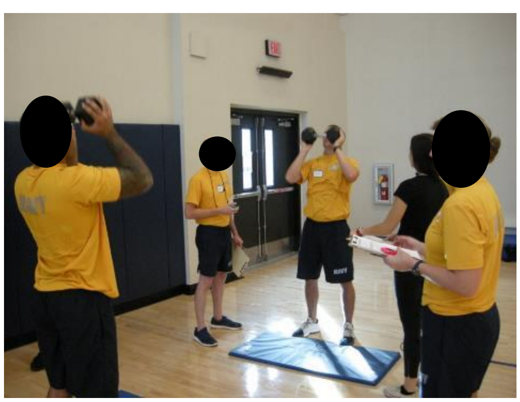

Figure 10. Participants performing the overhead weighted lift to assess upper body muscular endurance. (Photo courtesy of NHRC)

Vertical Jump: The vertical jump was proposed to assess lower body strength and power. Utilizing Vertec™ vertical jump test equipment (Sports Imports, Columbus, OH) (Figure 11), the participant had their standing reach measured to the nearest inch. The participant stood with both their feet flat on the deck with legs and torso straight. With a straight arm, wrist, and hand, they reached up and touched the highest bar possible with their fingers on the Vertec equipment. Next, the participant's jump reach was measured and scored. The participant was instructed to squat down and immediately follow up with a maximum effort vertical jump straight up as high as possible and, with a straight arm, swipe the Vertec device to move the bars at the highest point. No shuffle steps, side steps, drop steps, or gather steps were allowed. After each attempt, the bars on the Vertec were moved back into position. Vertical jump height was the difference, in inches, between the jump reach and the standing reach. The participant was given three attempts, and the highest vertical jump achieved was recorded as their official score.

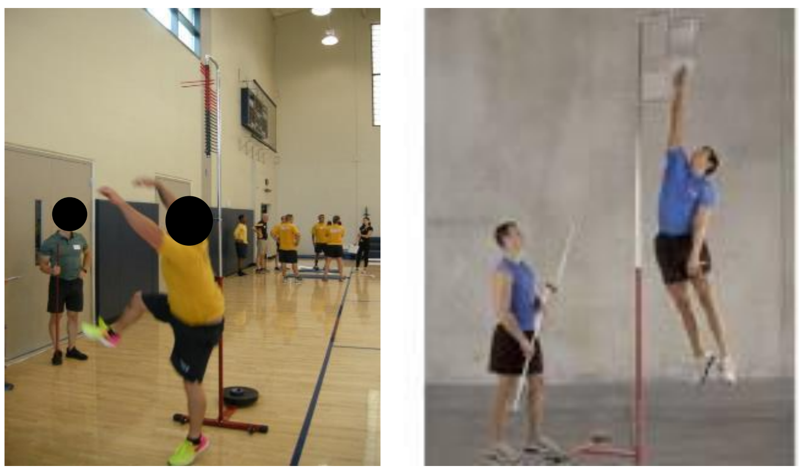

Figure 11. A participant performing the vertical jump (left; photo courtesy of NHRC). Example of the vertical jump technique using Vertec™ jump test equipment (right; Sports Imports, Columbus, OH).

Dummy Drag: The 165-lb dummy drag was proposed to assess total body strength. This untimed pass/fail event was conducted indoors.The participant grasped a 165-lb (74.84 kg) mannequin under the arms and by the handle(s) on the chest (either one or both handles were permitted), dragged it 35 ft (10.67 m) to a prepositioned cone, made a 180-degree turn around the cone, and continued an additional 35 ft (10.67 m) back to the finish line (Figure 12). The participant was permitted to drop and release the mannequin and adjust their grip and continue until the prescribed length of course was completed. The entire mannequin was dragged until it crossed the marked finish line.

Photo courtesy of NHRC

Figure 12. A participant performing the 165-lb dummy drag.

800-m Sprint: The 800-m sprint was proposed to assess anaerobic capacity. This was a timed event that was conducted outdoors on a 400-m track. The preparatory command was "Ready" and the execute command was "Go." Participants completed two laps around the 400-m track to reach the 800-m sprint distance (Figure 13). This event was conducted on a track to avoid numerous sharp turns that would force a participant to slow down excessively to remain on the course. Prior to conducting this event, study personnel ensured the running surface was free from hazards or debris that could cause injury to participants. Running this event on a treadmill was not authorized. The goal of this event was for participants to complete the measured course as quickly as possible.

Figure 13. An example of the 800-m sprint. (Photo by Mass Communication Specialist 2nd Class Jeffry Willadsen, Navy Public Affairs Support Element West, Det. Everett)

Data Analysis

For each of the 11 fitness modalities, box plots were created to depict the distribution of the participants' scores by gender. The line in the center of the box represents the median or 50th percentile, while the lower half of the box and the upper half of the box reflect the second quartile and third quartile, respectively. Lower and upper whiskers depict the 10th and 90th percentile, respectively, and scores falling either below or above the whiskers are illustrated by individual dots.

Each modality was qualitatively assessed and rated (low, moderate, or high) on six criteria to include: (1) feasibility (ease to administer and perform modality), (2) scalability, (3) safety of conducting the modality, (4) time efficiency (time requirement to administer modality), (5) cost efficiency (modality equipment cost), and (6) space efficiency (physical space requirements). A modality that rated “high” for each of the six criteria was considered optimal.

Pearson correlation analyses were performed to examine relationships between participants' performance on the new modalities to both their performance on traditional strength tests (1RM bench press, 1RM seated leg press, handgrip strength) and their most recent PRT (curl-ups, push-ups, 1.5-mi run) using historical Physical Readiness Information Management System (PRIMS) records. PRT run time was either represented by actual 1.5-mi run times ($n = 33$ participants) or predicted run times calculated from PRIMS algorithms for cycle ergometer ($n = 10$ participants). Any predicted run times calculated from PRIMS algorithms for the elliptical were not used. Pearson correlation analyses were also conducted to assess relationships within the modalities. Correlations were considered significant with a p-value of $p < 0.05$ (2-tailed). All data analyses were performed using GraphPad Prism 7 software (San Diego, CA).

RESULTS

Seventy-nine active duty sailors stationed at various commands onboard JBPHH were recruited and screened for eligibility to participate in this study. Forty-nine sailors were deemed eligible to participate and underwent the informed consent process; only 41 sailors [3 officers, 10 senior enlisted (E-7 and above), 28 junior enlisted (E-6 and below)] completed all components of the study. Participant physical characteristics are provided in Table 2. One of the primary eligibility criteria for a sailor's participation in the study was an overall score of “good” or better on their last two PRTs. Figure 14 illustrates the overall PRT performance score during cycle 2 2017 for the 44 sailors who completed some portion of the study. There was a fairly even distribution of scores for sailors of both genders among the three major categories consisting of good (males = 11, females = 5), excellent (males = 10, females = 2), and outstanding (males = 12, females = 4). Three sailors were dropped from the study for failure to complete all three testing days.

Table 2. Participant Physical Characteristics[a]

Participant	Age (yr)	Height (cm)	Weight (kg)	Body mass index (kg/m^2)
Males ($N = 30$)	31.3 ± 5.2	177.5 ± 7.6	87.3 ± 12.5	27.6 ± 3.3
Females ($N = 11$)	27.5 ± 5.1	159.8 ± 7.4	61.6 ± 10.0	24.2 ± 4.5

[a]Values shown are means ± standard deviation.

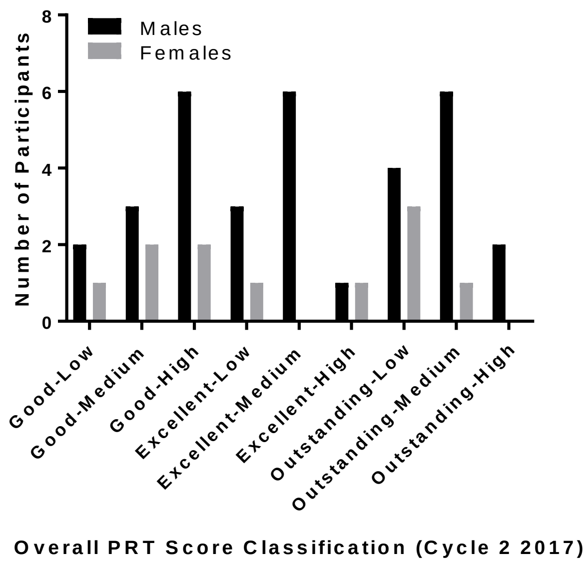

Figure 14. Gender-specific classification of participants' PRT performance.

Participants completed three traditional strength assessments on Day 1 in order to provide gold standard metrics for comparison with the results attained from the new potential PRT modalities. The 1RM bench press, 1RM seated leg press, and handgrip strength test are considered standard assessments of upper body strength, lower body strength, and total body strength, respectively. The box plots in Figure 15 illustrate the distribution of participant scores into quartiles for each traditional strength test for each gender. The lines extending vertically from the boxes (called "whiskers") indicate scores that fall within the 75th to 90th percentile (upper whisker from top of box) or within the 10th to 25th percentile (lower whisker from bottom of box). Scores that are outside these whiskers are presented as individual dots. Study participants also executed the forearm plank (Figure 16) as an assessment of core strength and endurance on Day 1. Figure 16 depicts the distribution of participants' scores by gender, with a maximum score of 300 s. The other 10 potential PRT fitness modalities were assessed on Days 2 and 3. Box plots graphically present the participants' scores by gender for upper body tasks (Figure 17), lower body tasks (Figure 18), a total body task (Figure 19), and timed runs and a sprint (Figure 20). All 41 participants successfully completed the untimed, pass/fail dummy drag.

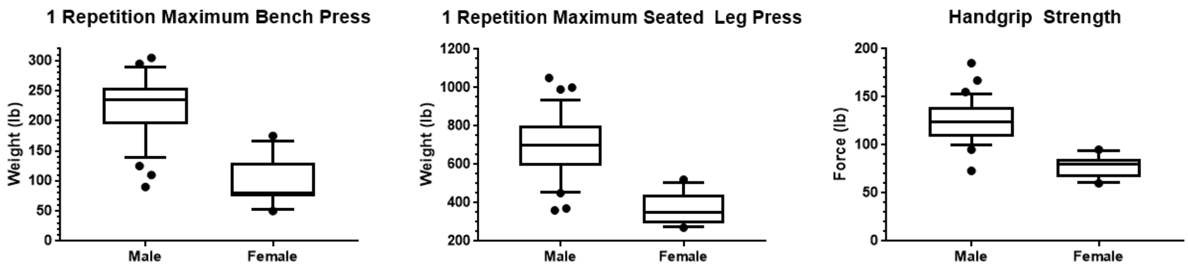

Figure 15. *Traditional strength tests*: 1RM bench press, 1RM seated leg press, and handgrip strength box-and-whisker plots display the distribution of scores for participants by gender.

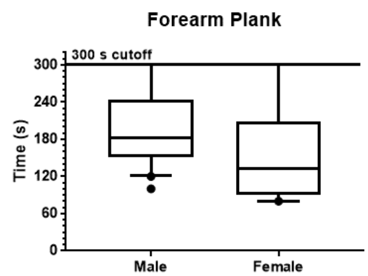

Figure 16. *Core strength modality*: Forearm plank box-and-whisker plots reflect the distribution of scores by gender.

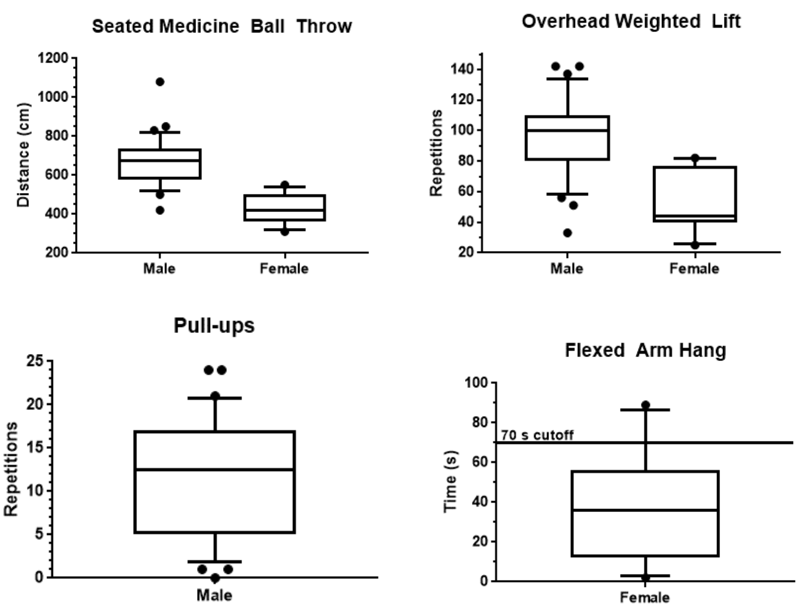

Figure 17. *Upper body modalities*: Seated medicine ball throw, overhead weighted lift, pull-ups, and flexed arm hang box-and-whisker plots display participants' scores by gender.

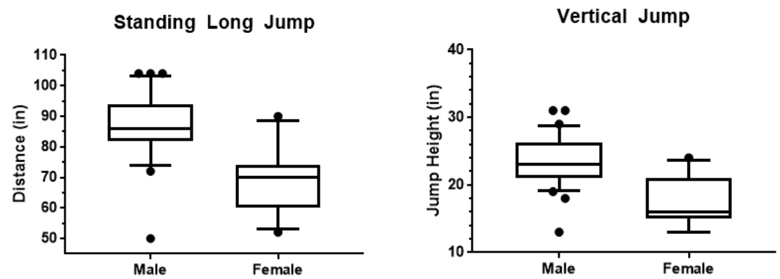

Figure 18. *Lower body modalities*: Standing long jump and vertical jump box-and-whisker plots reflect the range of participants' scores by gender.

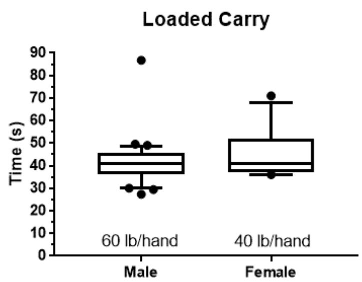

Figure 19. *Total body modality*: Loaded carry box-and-whisker plots illustrate the distribution of scores for participants by gender.

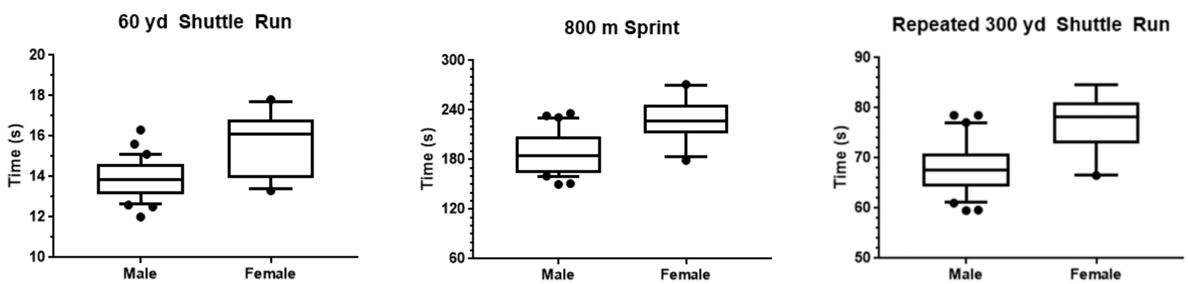

Figure 20. *Timed sprint and run modalities*: Shuttle runs (60 yd and repeated 300 yd) and the 800-m sprint box-and-whisker plots display the distribution of scores for participants by gender.

Each of the 11 new fitness modalities were qualitatively scored based on 6 parameters: feasibility, scalability, safety, time efficiency, cost efficiency, and space efficiency. Table 3 indicates the down-selection criteria for scoring each modality, grouped according to the body region being assessed. Modalities within each body region were then ranked, with a perfect score receiving "high" in each of the six categories. For upper body modalities, the overhead weighted lift had the highest score, followed by pull-ups and flexed arm hang, which received the same score. The seated medicine ball throw has the lowest score based on these down-selection critieria for upper body tasks. The standing long jump task scored the highest between the two lower body events based on cost (standing long jump map ~$70; Vertec vertical jump device ~$300). For total body events, the loaded carry had a much higher score than the dummy drag, which received a low score for scalability, safety, time, and cost efficiency. The 60-yd and repeated 300-yd shuttle runs scored equally well over the 800-m sprint, which requires a much larger space (ideally a 400-m track). Lastly, the forearm plank was the optimal task assessed, with high scores for all six down-selection criteria.

Table 3. Assessment of Modality Based on Down-Selection Criteria

Performance category	Modality	Feasibility	Scalability	Safety	Time efficiency	Cost efficiency	Space efficiency
Upper body	**Seated medicine ball throw**	Moderate	Low	High	Low	Moderate	Moderate
	Overhead weighted lift	High	High	Moderate	High	High	High
	Pull-ups	High	Moderate	High	Moderate	High	High
	Flexed arm hang	High	Moderate	High	Moderate	High	High
Lower body	**Standing long jump**	Moderate	Low	High	Low	Moderate	High
	Vertical jump	Moderate	Low	High	Low	Low	High
Total body	**Dummy drag**	High	Low	Low	Low	Low	Moderate
	Loaded carry	High	Moderate	Moderate	Moderate	High	Moderate
Runs/sprint	**60-yd shuttle run**	High	High	High	High	High	Moderate
	Repeated 300-yd shuttle run	High	High	High	High	High	Moderate
	800-m sprint	High	High	High	High	High	Low
Core	**Forearm plank**	High	High	High	High	High	High

The relationships between the three traditional strength tests and historical PRIMS scores for the three PRT components (curl-ups, push-ups, 1.5-mi run) and the 10 potential PRT modalities were examined (Table 4). There were strong correlations ($r > 0.7$) for upper body strength events between 1RM bench press and both the seated medicine ball throw and the overhead weighted lift. Other strong correlations for upper body endurance were between push-ups and both the pull-ups and the flexed arm hang. Strong correlations were also noted between the 1.5-mi run and both the repeated 300-yd shuttle run and 800-m sprint. Only moderate correlations (0.5 < *r* < 0.7) existed between lower body events (standing long jump, vertical jump) and 1RM seated leg press and 1.5-mi run. No significant relationships were determined for the core strength events (curl-ups, forearm plank) nor total body strength modalities (handgrip strength, loaded carry). Correlations could not be tabulated for the dummy drag since it was an untimed, pass/fail event. Relationships within the new PRT modalities were also examined and are depicted in Table 5. Strong correlations were found between the two lower body tasks (standing long jump and vertical jump), between the three runs/sprint events (60-yd shuttle run, repeated 300-yd shuttle run, 800-m sprint), and between lower body tasks and all three run/sprint events.

Table 4. Correlations Between Traditional Strength Tests/PRIMS Scores and New Fitness Modalities

	SMBT	OWL	Pull-ups	FAH	SLJ	VJ	Loaded carry	60-yd shuttle run	Repeated 300-yd shuttle run	800-m sprint	FP
1RM BP	0.79	0.72	0.43	NS	0.67	0.75	−0.49	−0.72	−0.59	−0.57	NS
1RM SLP	0.66	0.62	NS	NS	0.50	0.50	−0.39	−0.53	−0.37	−0.36	NS
Handgrip strength	0.76	0.56	NS	NS	0.56	0.63	−0.35	−0.61	−0.51	−0.49	NS
PRIMS push-ups	0.43	0.65	0.76	0.77	0.59	0.62	NS	−0.61	−0.51	−0.73	0.51
PRIMS curl-ups	NS	NS	0.68	NS	NS	NS	NS	NS	−0.51	−0.53	0.39
PRIMS run time	−0.32	−0.52	−0.63	NS	−0.59	−0.60	NS	0.48	0.82	0.89	−0.47

1RM, 1 repetition maximum; BP, bench press; FAH, flexed arm hang; FP, forearm plank; SLJ, standing long jump; SLP, seated leg press; SMBT, seated medicine ball throw; OWL, overhead weighted lift; PRIMS, Physical Readiness Information Management System; VJ, vertical long jump.
Run times for PRIMS scores from cycle 2 2017 reflect existing run times and predicted run times based on alternative test performance.
Correlations are significant at $p < 0.05$ (2-tailed). NS indicates no significant correlation.

Table 5. Correlations Between New Fitness Modalities

	SMBT	OWL	Pull-ups	FAH	SLJ	VJ	Loaded carry	60-yd shuttle	Repeated 300-yd shuttle	800-m sprint	FP
SMBT	1	0.55	NS	NS	0.63	0.65	−0.51	−0.70	−0.56	−0.45	NS
OWL	_	1	0.44	NS	0.53	0.45	−0.37	−0.56	−0.60	−0.66	0.49
Pull-ups	_	_	1	N/A	0.55	0.59	NS	−0.37	−0.64	−0.72	NS
FAH	_	_	_	1	NS	NS	NS	NS	NS	−0.81	0.87
SLJ	_	_	_	_	1	0.84	−0.57	−0.86	−0.80	−0.69	NS
VJ	_	_	_	_	_	1	−0.44	−0.76	−0.78	−0.68	NS
Loaded carry	_	_	_	_	_	_	1	0.47	0.43	NS	NS
60-yd shuttle	_	_	_	_	_	_	_	1	0.75	0.59	NS
Repeated 300-yd shuttle	_	_	_	_	_	_	_	_	1	0.92	−0.42
800-m sprint	_	_	_	_	_	_	_	_	_	1	−0.60
Forearm plank	_	_	_	_	_	_	_	_	_	_	1

FAH, flexed arm hang; FP, forearm plank; OWL, overhead weighted lift; SLJ, standing long jump; SMBT, seated medicine ball throw; VJ, vertical long jump.
Correlations are significant at $p < 0.05$ (2-tailed). NS indicates no significant correlation.

DISCUSSION

Factors Determining Modality Down-Selection

The Navy’s current biannual PRT, which evaluates only health-related components of fitness, does not provide a comprehensive assessment of a sailor’s physical or mission readiness. The objective of this investigation was to evaluate 11 modalities that assess performance-related components of fitness and to down-select the best 3–5 modalities to be potentially included in an alternative PRT. Modality down-selection was based on a number of factors, including:

1. Practical application of conducting the specific modality for both the Command Fitness Leader (CFL) proctoring the test and the sailor performing the task,
2. Ability of the new modalities to complement the current PRT,
3. Relationship between a sailor’s individual performance on each of the new modalities compared with their performance on traditional strength tests and their performance on the current PRT components using historical PRIMS data,
4. Selection of only one modality per category (upper body tasks, lower body tasks, total body task, timed runs/sprint, core task), and
5. Current guidance from relevant published literature on fitness testing.

Modalities Recommended for Inclusion in an Alternative PRT

Taking these five factors into consideration, the modalities recommended for inclusion in an alternative performance-based fitness test are the seated medicine ball throw, standing long jump, forearm plank, and repeated 300-yd shuttle run. Traditionally, military physical fitness testing modalities have been chosen on the basis that they require little to no equipment due to the need to test hundreds of service members at the same time. Thus, military physical fitness test design is inherently constrained by the ease of administration for large groups in field settings, minimal equipment and space requirements, and the time and cost burden. Based on the down-selection criteria and scoring alone (Table 3), the modalities that ranked the highest in each of the five categories (upper body, lower body, total body, timed runs/sprint, core) were as follows: overhead weighted lift, standing long jump, loaded carry, 60-yd shuttle run and repeated 300-yd shuttle run (scored equally), and forearm plank.

The practicality of each modality was not the only factor considered when evaluating the new fitness tasks. The recommended modalities were also selected because they complemented the current PRT events, not replaced them. The PRT assesses health-related fitness and provides a benchmark level of fitness required to reduce the risk of disease. The health-related components assessed in the PFA are body composition, muscular endurance (curl-ups, push-ups), and aerobic capacity (1.5-mi run, 450-m/500-yd swim, 12-min bike). In contrast, the 11 new fitness modalities under consideration are performance-based fitness tasks used to assess muscular strength and power, balance and coordination, agility, reaction time, and anaerobic capacity. Therefore, to prevent redundancy between the current PRT and a new performance-based fitness test, modalities that primarily assessed muscular endurance (overhead weight lift, pull-ups/flexed arm hang) or aerobic capacity (800-m sprint) were not selected.

A number of limitations with the current study should be considered when analyzing the study results. The study participants may not accurately reflect the entirety of the Navy's active duty population since these sailors are from only one geographical location, are of average or greater fitness level, and range from 20 to 42 years of age. Study measurements may be impacted by intertester variability when assessing more subjective fitness events, despite tester training. Lastly, calculated correlation strength between the participant's performance on the new modalities and their performance on their historical PRT scores may have been higher if the current study required participants to complete a best-effort PRT. To further examine the rationale for inclusion of these specific four modalities in an alternative PRT, the down-selected modality for each category will be discussed at length considering the five factors listed above.

Seated Medicine Ball Throw

The seated medicine ball throw is one of the most commonly used field tests to evaluate upper body power because it is easy to administer and has direct specificity of this movement to functional tasks such as rapid punching of combat athletes (Clemons, Campbell, & Jeansonne, 2010). Although the seated medicine ball throw is simple to perform, it does not have the most favorable practical application profile (Table 3) because it is not as scalable, nor as time, space, or cost efficient as the other upper body modalities. On the other hand, the seated medicine ball throw was the only upper body task that assessed upper body strength and power. The other three upper body tasks (overhead weighted lift, pull-ups, flexed arm hang) primarily evaluated upper body muscular endurance, which is already assessed with the push-ups in the current PRT. The seated medicine ball throw also had the strongest correlation between the upper body tasks and the 1RM bench press ($r = 0.79$), which is the gold standard assessment for upper body strength.

Recently, the Army implemented a new Occupational Physical Assessment Test (OPAT) for potential recruits and for soldiers wanting to switch their military occupational specialty (MOS). The OPAT was designed as a screening tool to predict who would be successful in completing the physically demanding tasks of a combat arms soldier (Foulis et al., 2017). One of the components of the OPAT is the 2-kg seated medicine ball throw to evaluate upper body power, which is needed in repetitive but generally stationary tasks such as loading ammunition. A 1985 Navy study showed that 84% of all common shipboard tasks involved lifting, carrying, and pulling, activities that intrinsically require muscular strength and power (Robertson & Trent, 1985). This fact underscores the need to have a performance test to evaluate this mission-critical fitness component as part of assessing a sailor's physical readiness. Fortunately, medicine balls are common equipment in today's Navy Operational Fitness Fueling Series section of Navy fitness centers, where sailors and CFLs could easily employ medicine ball training to improve test performance, overall upper body strength and power, and physical readiness if the seated medicine ball throw were to be incorporated into a fitness test. Given these points, the seated medicine ball throw is a commonly used, valid measure of upper body strength and power that is already being employed to assess operational readiness in the U.S. Army.

Standing Long Jump

Jump tests, such as the vertical jump and standing long jump, are validated, reliable, and frequently used field tests to assess lower body strength and power. Nothing in the current PRT assesses this aspect of performance fitness. The vertical jump and standing long jump have very similar practical application profiles (Table 3), with the exception of cost. They can both be administered very inexpensively with little more than some chalk and a tape measure; however, this method places more burden on the CFL and requires more time and skill. For ease of administration as well as providing standardization, this study utilized specific equipment designed for assessing these field tests. Of note, the standing long jump mat is significantly less expensive (~$70) than the vertical jump device (~$300). Although only moderate correlations were calculated for both jump tests ($r = 0.50$) with the 1RM seated leg press, a test of lower body strength, significant correlations have been reported between standing long jump ability and absolute 1RM back squat (Blackburn & Morrissey, 1998). A possible explanation for not reporting strong correlations between the jump tests and the seated leg press during this study may be due to the participants' inexperience with the seated leg press equipment. Many of the sailors who frequently participated in resistance training had never attempted a 1RM seated leg press, but they were familiar with performing the 1RM back squat. Researchers purposefully chose the 1RM seated leg press over the 1RM back squat as the measure of lower body strength for safety reasons, since not all of the sailors regularly participated in resistance training. Moreover, it is imperative to execute a back squat with proper form to prevent lower back and knee injuries, whereas the back is supported intrinsically by the back rest of the seated leg press machine.

The standing long jump has frequently been used in testing members in different branches of the military both domestically and internationally (Harman et al., 2008). One study, which evaluated various field tests for their ability to predict performance on simulated battlefield tasks, found the jump tests (vertical jump and standing long jump) were the best predictor (Harman et al., 2008). This finding was attributed to the fact that lower body explosive power, measured by jump tests, correlates with the repetitive high-intensity, short-duration tasks that occur on the battlefield. Thus, results from this study suggest that improving a service member’s jump ability could translate to better performance and increased survival on the battlefield (Harman et al., 2008). The standing long jump has been recommended over the vertical jump because it is more operationally relevant in regard to one’s ability to traverse and accelerate between obstacles. Additionally, the standing long jump has a balance and coordination component, which is not required with the vertical jump. The U.S. Navy has previously examined the standing long jump as a potential alternative PRT event and reported that it showed high test–retest reliability (Whitehead, Schilling, Peterson, & Weiss, 2012). The Army considered including the standing long jump in its new version of the Army Physical Fitness Test (APFT), although the new APFT was never implemented (Knapik et al., 2002). The Army did include the standing long jump in the new OPAT as a measure of lower body power needed in physically demanding MOSs that require repetitive lifting and carrying tasks such as offloading supplies or ammunition. Thus, the standing long jump is recommended over the vertical jump because it is the more cost effective, operationally relevant modality that measures not only lower body strength and power but also has a balance and coordination component.

Forearm Plank

The current Navy PRT assesses core muscular endurance with the curl-up; however, the repeated spinal flexion movement of the curl-up is not operationally relevant and promotes and/or aggravates low back injuries. Both bent-knee sit-ups and curl-ups do not strongly challenge the abdominal musculature, but instead employ hip flexor activity, especially as the participant becomes fatigued (Childs et al., 2010). Because these spinal flexion movement patterns generate substantial compressive and shear forces on the intervertebral discs and within the lumbar spine, sit-ups and curl-ups are not recommended for individuals with chronic low back pain (McGill, 2007; Rasmussen-Barr, Nilsson-Wikmar, & Arvidsson, 2003). Furthermore, traditional sit-ups have been reported to cause various degenerative spinal injuries due to the increased compression forces on the spinal column (McGill, 2010). For these reasons, core stabilization exercises, such as the forearm/horizontal plank, have been put forth as alternative methods to assess and develop core muscular endurance. The primary function of the abdominal musculature is to isometrically contract and act as stabilizers to stop, not start motion (Peterson, 2013). Planks incorporate an isometric contraction to activate key abdominal and trunk muscles (transversus abdominis, multifidus, erector spinae, quadratus lumborum), thereby mimicking the main function of the abdominal musculature, which is to resist the spine from moving while strengthening the lower back (Gottschall, Mills & Hastings, 2011). Core strength is important for controlling forces across the lumbar spine in order to produce and transfer energy to the distal limbs for functional and operationally relevant tasks, such as pushing, pulling, lifting, and carrying.

Data from the current study show the forearm plank is a highly feasible, scalable, safe modality that is also cost, time, and spatially efficient (Table 3). There was only a weak correlation reported between sailor performance on the forearm plank and performance on the PRT curl-ups ($r = 0.39$) from cycle 2 2017. A potential explanation for this finding could be reflective of the different musculature and movement patterns required in the two different tasks. Curl-ups are a spinal flexion movement that primarily activates the rectus abdominis and hip flexors. The forearm plank involves an isometric contraction that activates almost twice as much musculature, including the abdominal muscles, obliques, spinal erectors, and, to a lesser extent, muscles in the glutes, shoulders, chest, and arms (Gottschall, Mills & Hastings, 2011). Concerns have been raised as to whether replacing the curl-up with the forearm plank just substitutes one subjective assessment for another; however, recent literature suggests the plank may be less subjective than the traditional sit-up and curl-up tests (Strand, Hjelm, Shoepe, & Fajardo, 2014). Both sit-ups and curl-ups are dynamic assessments that require subjective determination of proper form for each repetition (Strand et al., 2014). For this reason, CFLs need to be highly trained in order to ensure test validity and reliability. In contrast, the forearm plank is a static test that begins when the participant initiates the correct starting position and ends when the participant fails to maintain the correct starting position/posture.

Both the Navy and Army have previously investigated the forearm plank as a replacement for the bent-knee curl-up or sit-up, respectively. The Navy examined the single-leg plank in both civilian and active duty personnel because this plank variant added a balance component (Whitehead et al., 2012). It was hypothesized that the single-leg plank would be more difficult to perform, thereby requiring less time to execute (Whitehead et al., 2012). That study found that the single-leg plank had a low test–retest reliability [coefficient of variation (CV) = 21.3%] and recommended future testing include the standard two-legged front plank (Whitehead et al., 2012). The Army study explored whether a 16-week training program that used core stabilization exercises would decrease musculoskeletal injury incidence and work restriction duration compared with a traditional sit-up training program. The incidence of musculoskeletal injuries was similar between groups, with lower back injuries accounting for the second largest category of injury (Childs et al., 2010) behind lower extremity injuries. Be that as it may, soldiers who sustained lower back injuries but were in the core stabilization exercise group had fewer days of work restriction and could return to duty sooner than those soldiers in the traditional sit-up training group (Childs et al., 2010). This finding is in line with current guidance from the literature that supports using core stabilization exercises to prevent and treat lower back pain (Rasmussen-Barr et al., 2003). In another Army study, a 12-week traditional sit-up program was compared with a 12-week core stabilization exercise program on sit-up performance during the biannual APFT (Childs et al., 2009). Both groups significantly improved sit-up performance on the APFT, but the core stabilization exercise group had a greater increase in sit-up pass rate than the traditional sit-up group (Childs et al., 2009). As stated above, there is substantial evidence to support replacing the curl-up with the forearm plank as an assessment of core muscular endurance. Not only is the forearm plank easy to administer, but it effectively prevents and treats low back injury while building core strength, which is the foundation of all functional movements and operationally relevant tasks.

Repeated 300-yd Shuttle Run

The current study evaluated the 60-yd shuttle run, the repeated 300-yd shuttle run with a 5-min rest in between efforts, and the 800-m sprint as the timed runs under consideration. The 60-yd shuttle run evaluates speed, agility, coordination, and reaction time, while the repeated 300-yd shuttle run measures anaerobic capacity and agility. The 800-m sprint assesses a combination of aerobic and anaerobic capacity, depending on the fitness level of the participant and/or how long it takes the individual to complete. All three runs had similar practical application profiles (Table 3). They are all highly feasible, scalable, safe, and time and cost efficient; however, the 60 yd and repeated 300-yd shuttle runs require less space. Ideally, the 800-m sprint should be conducted on a 400-m circular track or in an area large enough to avoid sharp turns to prevent the need to slow down, which would negatively impact a service member's sprint time. Both the repeated 300-yd shuttle run (r = 0.82) and the 800-m sprint (r = 0.89) had a strong correlation with participants' historical 1.5-mi run time from cycle 2 2017. This strong correlation indicates that both events could serve as a surrogate for the 1.5-mi run as a measure of aerobic capacity; however, the repeated 300-yd shuttle run is more desirable when space limitations exist and because it provides an agility component.

Currently, all branches of the U.S. military use a distance run to evaluate service members' aerobic capacity. This can lead to lower body overuse injuries when service members participate in high-volume running as they "train to the test." The Army reported 75% of males and 78% of females sustained injuries during basic combat training, many of which occurred in the lower back and lower body and were associated with distance running (Evans et al., 2003). As a result, interval training (i.e., shuttle runs) has been recommended as an approach to building speed, stamina, and preparing for the APFT without requiring service members to participate in excessive running volume (Evans et al., 2003). Shuttle run training intrinsically involves frequent changes in direction, which improves change of direction speed and is more operationally relevant than straight line running (Roy et al., 2010). Current military physical training guidelines recommend participating in both straight line running to increase straight line speed as well as change of direction running (Roy et al., 2010). Although the Army (Knapik et al., 2002) and Navy (Whitehead et al., 2012) have previously evaluated the 300-yd shuttle run (singular not repeated version as presented in this study), neither service has implemented it in its biannual physical fitness tests. Regardless, Whitehead et al. (2012) reported high test–retest reliability (CV = 2.2%) and suggested the training effects may improve body composition in addition to overall aerobic performance.

Foreign military services have begun to use shuttle runs in place of distance runs to evaluate their service members' aerobic capacity (Aandstad, Holme, Berntsen, & Anderssen, 2011). Shuttle run tests provide many benefits: they are easy and time efficient to administer, they correlate well with VO_2max tests (gold standard for measuring aerobic capacity), and they evaluate an individual's anaerobic capacity, lactate threshold, running economy, and the ability to tolerate high levels of fatigue, which are important operationally relevant attributes (Aandstad et al., 2011). Moreover, a recent study that evaluated field tests as predictors of simulated battlefield performance determined the average duration of simulated battlefield tasks was 43–84 s (Harman et al., 2008). This finding suggests that performance on the 300-yd shuttle run may be a better predictor of mission readiness because the duration closely matches that of battlefield tasks (repeated 300-yd shuttle run average scores: males = 68.1 ± 5.2 s; females = 76.6 ± 6.2 s). Overall, the repeated 300-yd shuttle run was recommended for inclusion in an alternative PRT because it directly measures anaerobic capacity and agility while strongly correlating with the 1.5-mi distance run. Thus, this shuttle run can serve as a surrogate indicator of aerobic capacity especially when physical space constraints exist. Furthermore, training for the repeated 300-yd shuttle run will engage service members in change of direction interval training, enhancing operationally relevant fitness components without employing potentially injurious high-volume running loads.

Modalities Not Recommended for Inclusion in an Alternative PRT

Total Body Tasks

The dummy drag and loaded carry were the two total body tasks evaluated in this study; however, neither was recommended for inclusion in an alternative PRT. The current PRT does not assess total body strength or power, so neither of the two tasks under consideration would have provided any redundancy if selected. From a practical application aspect, the loaded carry ranked above the dummy drag in terms of scalability and safety, as well as time and cost efficiency. The 165-lb dummy costs ~$2,000 including shipping fees, which would limit the number of dummies purchased by an installation, thereby impacting scalability and the time to administer the task. More importantly, there is a greater risk for sailors sustaining low back injuries and other musculoskeletal injuries while performing the dummy drag task due to improper lifting techniques. The dummy drag was conducted as an untimed, pass/fail event, which does not permit a graduated range of norms to be established, unlike every other fitness modality under consideration. Although the loaded carry uses common equipment found in Navy fitness centers, thereby being more scalable and time and cost efficient, it requires a larger space and should be conducted outdoors to avoid damaging the floor or deck in the event the weights are dropped. Additionally, the loaded carry only demonstrated weak correlations to performance on the traditional strength tests, thus suggesting that the loaded carry does not accurately reflect total body strength ($r = -0.49$ 1RM bench press; $r = -0.39$ 1RM seated leg press; $r = -0.35$ handgrip strength). Correlations for the dummy drag could not be calculated because it was an untimed event.

Research staff noted that several sailors had difficulty maintaining their handgrip strength to carry the dumbbells throughout the loaded carry course without setting them down to readjust their grip, which negatively impacted their time. Moreover, it is likely that this task does not represent a real-world scenario, since individuals tend to carry heavy loads by employing larger muscle groups, such as carrying a load on the shoulders. Nevertheless, both total body tasks involved moving an absolute load (dummy or dumbbells) a set distance, which provides an intrinsic advantage to heavier individuals over lighter individuals because they will be working at a lower relative workload. Since the goal of this study was to recommend modalities for a performance-based fitness test, not an occupational fitness test, it does not make sense to use absolute loads. Total body strength should be assessed relative to the individual's body weight, which cannot be effectively executed with either of these two tasks as they were conducted. In summary, a total body task was not selected for inclusion in a future alternative PRT because neither task accurately assessed total body strength and the dummy drag poses too great of a risk to sailors of sustaining a musculoskeletal injury.

CONCLUSIONS

The current Navy PRT, which sets the standards for cardiovascular and muscular endurance, is insufficient to assess sailor's overall physical fitness and mission readiness. As it stands, this test does not measure performance fitness components like speed, agility, balance, coordination, reaction time, strength, and power, which are required for performing functional movement patterns within the battlespace. Both the Marine Corps and the Army have an occupational fitness test; however, this one-size-fits-all approach is not applicable to the Navy, which has almost 50 different enlisted rates and 8 staff officer corps, in addition to the regular line, limited duty, and warrant officer communities. Moreover, those naval communities that have physically demanding jobs already have established their own occupational physical screening tests. However, it is important to establish a generalized performance-based test in addition to the current PRT that requires sailors to train year round on a variety of different endurance and strength training exercises in order to perform well on these assessments. Admittedly, sailors tend to train for the test. This concept is supported by Whitehead et al. (2012) who found that 21.6% of 88 sailors self-reported they "seldom-to-never" participated in regular strength training. Therefore, unless there is an impetus to necessitate regular training of other components of fitness (e.g., a strength-dependent fitness task), sailors are not likely to change their established routines. With this in mind, policy makers are provided the opportunity to positively influence sailors' behavior patterns, specifically their physical training regimen.

The current study results support including the seated medicine ball throw, standing long jump, forearm plank, and repeated 300-yd shuttle run in a performance-based fitness test. This new test would enhance the accuracy of assessing sailors' fitness levels and operational readiness and provide operational commanders with advanced knowledge of the physical capabilities and/or limitations of their personnel. This information could be further used to aid in task force selection for strenuous tasks, to develop physical training programs to augment specific physical weaknesses critical to mission performance, and to evaluate the effectiveness of physical training programs. However, before an alternative PRT could be launched, these modalities would need to be validated in a follow-on large-scale study in order to develop the appropriate norms and performance standards across gender and age brackets.

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