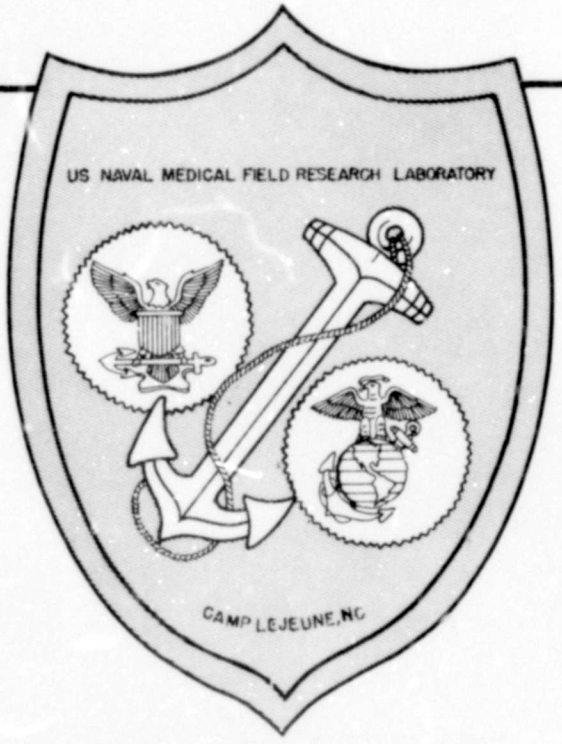

U.S. NAVAL MEDICAL FIELD
RESEARCH LABORATORY
CAMP LEJEUNE, NORTH CAROLINA

Vol. XX, No. 22 November 1970

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Philip J. Rasch, Ph.D., and Captain John J. Krauer, USMC

Bureau of Medicine and Surgery, Navy Department
Work Unit MF12.524.007-8013BA8X.16

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Philip J. Rasch, Ph.D.

Physiology Division
NAVAL MEDICAL FIELD RESEARCH LABORATORY
Camp Lejeune, North Carolina 28542

and

Captain John J. Krauer, USMC
Physical Fitness Academy, Quantico, Virginia

Bureau of Medicine and Surgery, Navy Department
MF12 524.007-8013BA8X.16

Submitted by:

PHILIP J. RASCH, Ph.D.
Chief
Physiology Division

Approved by:

JESSE F. ADAMS
CAPT MC USN
Commanding Officer

SUMMARY PAGE

THE PROBLEM

To determine the validity of the two-minute bent knee sit-up.

FINDINGS

1 This event apparently does not measure the strength of the abdominal muscles and hip flexors to a significant degree.

2 It seems to be primarily a measure of trunk flexion speed and secondarily a measure of the endurance of the abdominal muscles and hip flexors

RECOMMENDATION

It is recommended that further study of this event be undertaken in an attempt to validate this item.

ADMINISTRATIVE INFORMATION

Bureau of Medicine and Surgery, Department of the Navy, Work Unit MF12.524.007-8013BA8X, report 16 Interim report. Approved for publication 21 October 1970.

Published by the Naval Medical Field Research Laboratory, Camp Lejeune, N.C. 28542.

ABSTRACT

The U.S. Marine Corps Physical Fitness Test includes a two-minute bent knee sit-up. The purpose of this study was to investigate the validity of this item. It was concluded that this test does not measure the strength of the abdominal muscles and the hip flexors to a significant degree. Apparently it is primarily a measure of trunk flexion speed and secondarily a measure of the endurance of the abdominal muscles and hip flexors.

STATEMENT OF THE PROBLEM

Technical standards for any test battery require that the individual items be reliable, that is, give consistent results when administered repeatedly, and valid, that is, measure what they purport to measure At the time the present USMC Physical Fitness Test was designed, no reliability or validity determinations were undertaken. Consequently, the user of this battery does not know precisely what it measures nor how good a job of measurement it does. These parameters will be studied as time and the opportunity to gather data permit. The present paper reports an investigation of the validity of the two-minute bent knee sit-up.

BACKGROUND

Kinesiological analysis suggests that adequate trunk strength is a matter of importance to the combat Marine. The spine is a flexible weight-bearing column which depends upon muscular strength for both lateral and anterior-posterior stabilization. In normal easy standing, the body's center of gravity constantly shifts, so that the individual is continually swaying on a stationary base. Equilibrium is largely maintained by alternate contractions of the muscles on the front and back of the trunk. There is continual contraction of the internal oblique muscles of the abdomen, possibly to protect the inguinal region from herniation,[1] and of the iliopsoas to prevent hyperextension of the hip.[2]

Joseph and Williams[3] and Carlsoo[4] were unable to detect any electrical activity in the iliacus and psoas muscles during easy standing, but, in both cases, surface electrodes were used and the likelihood that surface electrodes will pick up potentials from such deep muscles is rather remote. Basmajian[5] contends that they show slight to moderate activity and are postural or stabilizing muscles as a flexor of the hip joint. There is general agreement that when a load is carried low on the back, its backward pull is offset by a forward inclination of the trunk, resulting from contraction of the psoas muscles.[6] Probably the necessity for back packing provides the primary justification for the inclusion of a measure of trunk strength in Marine Corps physical fitness tests. However, Shvartz[7] suggests that good condition of the abdominal muscles is a determining factor in the prevention of orthostatic inefficiency (circulatory collapse induced by gravity). This could conceivably be of some importance in prolonged standing at attention, for instance. Shvartz reported high correlations between good orthostatic adjustments and the number of sit-ups and push-ups performed.

The measurement of trunk muscle strength in the human is a matter of considerable complexity. The length of the bony levers involved is obviously affected by the subject's height. The weight of the body segments to be moved will be affected by his body build. The measured force exerted will be altered as the angle of pull changes with the movement of the bony levers by the muscles. Variations in the way the exercise is done may affect the results. A rather elaborate table has been designed by Walters and Harris[8] for the specific purpose of measuring abdominal strength and endurance, but an apparatus of this kind is seldom available outside of a well-equipped laboratory and requires trained technicians to use it.

Traditionally, in testing in the field, "abdominal strength" has been measured by the number of sit-ups and/or leg raises which the Marine can perform This has drawn support from such studies as Phillips[9] factor analysis of a number of physical education tests which resulted in her identifying a factor designated "abdominal strength" because of its correlation with three sit-up tests.

When the sit-up is done with the knees extended and the ankles held, the psoas, iliacus, rectus abdominis, vastus lateralis, tensor fascia latae, obliquus externus, obliquus internus, and rectus femoris are involved. Third class leverage is involved in the flexion at the hip joint.[10] The test is moderately reliable; a test-retest coefficient of 0.71 was found in a study of aviation personnel [11]

Flint[12] reported that trunk flexion up to about 45 degrees and control of return to the supine position was the function of the abdominal muscles. She found that it made little difference on the magnitude of the action potentials whether the knees were flexed or extended, as the pattern of muscle action was similar for all types of sit-ups. The kinesiology of various kinds of sit-ups and of leg raises has been discussed at some length by Rasch and Burke.[13]

Since World War II the validity of sit-ups as a measure of "abdominal strength" has been under constant attack As early as 1944, DeWitt had found a correlation of only 0.14 between abdominal strength as measured by the pull a man could exert against a dynamometer while lying supine on a table and the number of sit-ups an individual could do in two minutes He concluded that there was a "definite question of the justification for calling the sit-up test a test of strength and endurance of the abdominal muscles."[14] Wedemeyer has reported that the correlation between strength of the abdominal muscles as measured by the Martin Breaking Method and the number of sit-ups which can be done in two minutes is 0.45, while that between strength and the maximum number of sit-ups is only 0.12 He suggested that "sit-ups measure a combination of strength and endurance . . . of the abdominal and thigh flexor muscles."[15] Cousins agreed "that sit-ups and variations of sit-ups are more indicative of the strength of the trunk flexors than of the abdominal muscles . . The abdominal muscles do come into action to some extent in the correct performance of sit-ups; however, they are not the principal muscles involved. If strengthening the abdominals is to be one of the major considerations of military tests, some other test must be employed which will more adequately measure abdominal strength."[16]

Kendall[17] contends that sit-ups are not valid tests of abdominal strength, because they involve the action of the hip flexor muscles A review of factor analytic studies resulted in Nicks and Fleishman[18] recommending the number of sit-ups which an individual could do in 30 seconds and the number of leg raises which he could do in 30 seconds as measures of the dynamic strength of the trunk Fleishman, however, has since concluded that leg lifts are a more satisfactory criterion, characterizing sit-ups as an "imperfect" measure.[19]

The U S Marine Corps Physical Fitness Test includes a measurement of the number of bent knee sit-ups which can be performed in two minutes. Since a few individuals are able to accomplish a very high number of repetitions in an untimed event of this kind and thus delay an entire testing program, some sort of a time limit becomes an administrative

necessity. However, this introduces certain difficulties. Karpovich[20] has reported that the correlation between the number of straight leg sit-ups which can be done in three minutes by Army Air Force basic trainees and those which can be done in an unlimited time is 0.54, which he considers too low to justify substituting the former for the latter in individual testing. Correlations for one, two ($r = 0.43$), four, and five minutes were even lower. Berger[21] reported a considerably higher, $r = 0.712$, relationship between the number of straight leg sit-ups which could be done in two minutes and the number that could be performed without a time limit. Even this gives a predictive index of only 30%.* He found a coefficient of correlation between one sit-up with maximum load and the two-minute timed sit-up of only 0 508; between one sit-up with maximum load and sit-ups without a time limit, it was 0 518

PROCEDURE AND RESULTS

One hundred students at the Officer Candidate School (OCS),† Quantico, served as subjects for the first phase of this study These men were routinely administered the School's physical performance test, consisting of the one-minute squat thrust, two-minute push-ups, two-minute straight leg sit-ups, and 300-yard run. In addition, they were given a 12-minute run for distance and a two-minute bent knee sit-up. One man dropped out part way through the testing program. Means and standard deviations for each test event are shown in Table 1 Intercorrelations for these events are shown in Table 2, from which it will be seen that two-minute bent knee and two-minute straight leg sit-ups had only a moderate correlation ($r = 0.54$) with each other. There is no indication from these figures that either method is superior for testing purposes, but there would be little to be gained by including both forms in a single battery. Presumably the fact that the correlation between the two is only moderate is attributable to the fact that the role played by the iliopsoas and abdominal muscles is not the same in the two exercises.

TABLE 1

Means and Standard Deviations of Test Scores (N = 99-100)

Event	Mean	S.D.
One minute Squat Thrust	22.3	4.3
Two minute Push ups	30 3	10.2
Two minute Straight Leg Sit-ups	48.7	13.5
300-yard Run	52.4 sec	3.8 sec
Two-minute Bent Knee Sit-ups	55.6	14.3
12 minute Run	2875.1 yd	247 6 yd

The correlation between either form of sit-ups and the other test items was low In other words, sit-ups are orthogonal to the other tests which were administered.

*The Predictive Index is computed as $PI = 1 - \sqrt{1 - r^2}$. Thus $r = 0.712$ gives a figure 30% better than chance in predicting performance

†The authors are indebted to Colonel H E Ing, USMC, Commanding Officer, Officer Candidate School, Quantico, Va for his cooperation in making troops available for this study

TABLE 2

Intercorrelations (r) of Test Events

	Squat Thrust		Two minute Push ups		Two-minute Straight Leg Sit-ups		300-yard Run		Two-minute Bent Knee Sit-ups		12-minute Run	
	N	r	N	r	N	r	N	r	N	r	N	r
Pull-up	100	0.20	100	0.53	100	0.25	100	-0.38	99	0.26	100	0.24
Squat Thrust			100	0.23	100	0.16	100	-0.05	99	-0.05	99	0.06
Push-up					99	0.28	99	-0.16	99	0.14	99	0.09
Two-minute Straight Leg Sit-up							99	-0.27	99	0.54	99	0.24
300-yard Run									99	-0.35	99	-0.17
Bent Knee Sit-up											99	0.01

During the second phase, 54 OCS students were administered the two-minute straight leg sit-up, the untimed straight leg sit-up, the two-minute bent knee sit-up, and the untimed bent knee sit-up over a period of several days. Means and standard deviations are shown in Table 3, and the intercorrelations of the four events are shown in Table 4. There is only a moderate correlation ($r = 0.63$) between the two-minute bent knee test and the untimed version and between the two-minute straight leg sit-ups and the untimed sit-ups. While this is highly significant, it is too low to have much predictive value.

It must be concluded that the two-minute sit-ups are not a satisfactory measure of hip flexor and abdominal muscle endurance as determined by untimed sit-ups. Presumably they measure speed of trunk flexion, and, to a limited extent only, the endurance of the trunk flexors and abdominal muscles. If the Marine Corps is to have a scientifically based physical fitness test battery, the need for further study of these problems is evident.

TABLE 3

Means and Standard Deviations of Sit-up Scores

Event	N	M	S.D.
Two-minute Straight Leg	155	59.0	11.5
Untimed Straight Leg	54	134.6	107.9
Two-minute Bent Knee	112	46.3	13.8
Untimed Bent Knee	58	74.5	70.4

CONCLUSIONS

1. The correlation between two-minute bent knee sit-ups and two-minute straight leg sit-ups is only moderate; that between the untimed bent knee sit-ups and the untimed straight leg sit-ups is low. Presumably this reflects the differing roles of the abdominal and iliopsoas muscles in these exercises.

TABLE 4

Intercorrelations of Various Types of Sit-ups
(N = 54)

	Untimed Straight Leg Sit-ups	Two-minute Bent Knee Sit-ups	Untimed Bent Knee Sit-ups
Two-minute Straight Leg Sit-ups	0.63	0.55	0.12
Untimed Straight Leg Sit-ups		0.63	0.30
Two-minute Bent Knee Sit-ups			0.59

2. The correlation between two-minute bent knee sit-ups and untimed bent knee sit-ups is moderate, but too low for predictive purposes. Apparently the two-minute bent knee sit-ups measure the endurance of the trunk flexors to only a limited extent.

3. The literature indicates that repetitive sit-ups of either kind do not measure the strength of the abdominal muscles and the hip flexors. This point should be investigated using Marines as subjects.

4. It is suggested that two-minute bent knee sit-ups measure trunk flexion speed and to a limited extent the endurance of the hip flexors and abdominal muscles.

5. As a test item, two-minute sit-ups are orthogonal to pull-ups, squat thrusts, push-ups, 300-yard run, and 12-minute run.

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Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY *(Corporate author)*

Naval Medical Field Research Laboratory
Camp Lejeune, North Carolina 28542

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3 REPORT TITLE

A STUDY OF THE VALIDITY OF THE TWO-MINUTE BENT KNEE SIT-UP

4 DESCRIPTIVE NOTES *(Type of report and, inclusive dates)*

Interim report

5 AUTHOR(S) *(First name, middle initial, last name)*

Philip J. Rasch, Ph.D.
John J. Krauer, CAPT USMC

6 REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO OF REFS
November 1970	12	21

8a. CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO MF12.524	MF12.524.007-8013BA8X.16
c. Task No. MF12.524.007	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d. Work Unit No MF12.524.007-8013BA8X	Vol. 20, No. 22

10 DISTRIBUTION STATEMENT

This document has been approved for public release and sale; its distribution is unlimited.

11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
	Bureau of Medicine & Surgery Navy Department Washington, D. C. 20390

13 ABSTRACT

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Physical fitness tests						
USMC Physical Fitness Test						
Two-minute bent knee sit-ups						
Bent knee sit-ups						
Sit-ups						