Conclusion

In the long run, these economic incentives to comply with JCAHO standards and the QA process may bring the U.S. medical establishment far closer to full compliance than in the past. The expected oversupply of physicians in the 1990s is also likely to contribute to a favorable environment for QA processes due to increased competition and "survival of the fittest," that is, those who deliver the highest quality care.

References

1. Joint Commission Forum: Monitoring and evaluation of the quality and appropriateness of care: a hospital example. QRB 12:326–330, 1986
2. Letters: More on the term "quality." QRB 13:410, 1986
3. Miller CL: An anesthesia QA program. QRC Advisor 3:1–6, 1987
4. Letters: The term "quality." QRB 12:310, 1986
5. Letters: The Joint Commission's model for monitoring and evaluation of quality care. QRB 13:74–75, 1987
6. O'Leary DS: Joint Commission to ascertain status of relationships among governing bodies, management, and medical staffs. JCAHO Perspectives 7:2–3, 1987
7. "Implementation monitoring" for designated standards. JCAH Perspectives 5:3–4, 1985
8. Implementation monitoring reports no longer required. JCAH Perspectives 6:5, 1986
9. QA update: Joint Commission sets agenda for change. QRB 13:148–150, 1987

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The Army Physical Fitness Test (APFT): A Review of the Literature

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This paper examines the literature on the Army Physical Fitness Test (APFT) as a measure of aerobic capacity and muscular strength/endurance. The APFT consists of a two-mile run, push-ups, and sit-ups. The two-mile run is a measure of aerobic fitness because this test is highly correlated with maximal oxygen uptake (VO_2max). Muscular strength and absolute muscular endurance are highly correlated, justifying the use of a single measurement for both. Studies using factor analysis showed that push-ups and sit-ups have moderate to high factor loadings on various muscular strength/endurance factors. However, there are methodological problems in relating these studies to the APFT.

Introduction

The Army Physical Fitness Test (APFT) promotes combat readiness by motivating soldiers to develop and sustain a high level of physical fitness.[1] The test consists of three items: a timed two-mile run, push-ups, and sit-ups. It is relatively simple to administer to many individuals in a short time. It requires no equipment other than paper, pencil, and stopwatches. Army Field Manual 21-20 (FM 21-20) describes the test in detail.[2]

FM 21-20 states that the APFT measures specific aspects of physical fitness.[2] It is difficult to clearly define physical fitness; however, aerobic capacity, muscular strength, and muscular endurance are among the more important components.[3,4] This paper will review the literature to determine whether the three APFT test items actually measure these components of fitness. A secondary purpose is to present a justification for combining the concepts of muscular strength and muscular endurance.

This paper will also review pull-ups and various modifications of this test. Pull-ups are not now an APFT test item, but the Soldier Support Center (Fort Benjamin Harrison, IN) proposed their use on several occasions. The reason for including modifications to pull-ups is that many people cannot perform a single pull-up, thus requiring use of a substitute test.

The Two-mile Run: A Measure of Aerobic Fitness

Oxygen used by the body is directly proportional to energy used when performing long-term physical exercise. Aerobic capacity (or aerobic fitness) is the body's ability to consume and use oxygen. An individual with higher aerobic capacity is able to perform submaximal physical tasks at a higher rate or for a longer time than an individual with a lower aerobic capacity.[5]

Maximum oxygen uptake (VO_2max) is the laboratory measure of aerobic fitness. There are many variations on this test. A typical test begins with an individual running on a treadmill. The speed and/or grade of the treadmill is progressively increased until the individual is too fatigued to continue. While exercising, the individual's expired air is collected and analyzed for its oxygen content. The individual's VO_2max is the point at which oxygen intake does not increase despite an increase in the exercise intensity.

There is a close relationship between VO_2max and the ability to run rapidly if the run distance is long enough. Table 1 shows this relationship by displaying studies that have correlated VO_2max and running times at a variety of distances. Generally, the correlations in Table 1 increase as the running distances increase.

Table 2 shows 12 studies that have investigated the relationship between running times and VO_2max. These studies examined distances of at least one mile or running times of at least six minutes. The majority show very high correlations, ranging from −0.29 to −0.94. All but four studies[7,8,15,16] show correlations ranging from −0.74 to −0.94. Of note, there are five studies that have specifically related two-mile run times to VO_2max. Four of these reported values ranging from −0.76 to −0.91. These data show a close relationship between the ability to run rapidly for a distance of two miles and aerobic capacity. Thus, the two-mile run serves as a valid index of aerobic fitness.

TABLE 1

CORRELATIONS BETWEEN VO_2MAX AND RUNNING TIMES AT VARIOUS DISTANCES

Running Distance	Ribisl et al.[6]	Shaver[7]	Wiley & Shaver[8]	Burke[9]
10 Yards				
50 Yards				
60 Yards	−0.14			
100 Yards	−0.23	−0.08		
220 Yards	−0.05	−0.25		
300 Yards				−0.52
440 Yards	−0.31	−0.29	−0.22	
600 Yards				−0.78
880 Yards	−0.67	−0.35	−0.29	
1Mile	−0.79	−0.43	−0.47	−0.74
2Miles	−0.85	−0.76	−0.43	
3Miles		−0.82		

TABLE 2

STUDIES EXAMINING THE RELATIONSHIP BETWEEN RUNNING PERFORMANCE AND VO_2MAX

Study (Ref. No.)	Subjects	Age (yrs)	Run Distance or Time	VO_{2max} Test	Correlation Between Run Time & VO_{2max}	VO_{2max} (ml/kg × min)	Run Time (min)
10	70 Army Officers	42.8 ± 1.9[a] (40–48)[a]	2 miles	TM[b] walk	−0.78	43.3 ± 4.8	15.5 ± 1.7
11	115 US Air Force Men	22 (17–52)	12 min	TM run	−0.90		
12	25 Lab workers	29.8 (17–54)	12 min	TM run	−0.94	44.1	12 (1.58 miles)
7	30 untrained college males	22.5 ± 3.2	1 mile	TM run	−0.43	53.5 ± 5.6	7.3 ± 1.1
			2 miles		−0.76		15.1 ± 1.8
			3 miles		−0.82		25.0 ± 2.5
13	100 males		12 min	Cycle ergometer[c]	−0.90	45.7 ± 8.6	12 (1.7 miles)
	50 females				−0.91	43.4 ± 8.5	12 (1.7 miles)
14	9 military workers	31 ± 2	2 km	Cycle ergometer[c]	−0.92	62.5 ± 2.5	
15	14 Marines		3 miles	TM run[c]	−0.65		29.6 ± 1.5
8	35 untrained college males	20.8 ± 2.2 (18–25)	1 mile	TM run	−0.29	52.6 ± 6.3	7.1 ± 0.9
			2 miles		−0.47		16.0 ± 1.7
			3 miles		−0.43		25.9 ± 2.6
16	40 college women	18.3 (18–21)	6 min	Cycle ergometer[c]	−0.45		
			9 min		−0.37		
			12 min		−0.49		
9	44 college men	22.2 ± 3.3	1 mile	TM	−0.74		6.7 ± 0.7
			12 min		−0.90		12 (1.7 miles)
17	44 males	31.3 ± 6.9	2 miles	TM run	−0.91	50.4 ± 7.7	14.7 ± 2.1
	17 females	28.3 ± 4.0	2 miles		−0.89	42.0 ± 6.0	17.5 ± 3.0
6	24 men	39.9 ± 6.2	2 miles	TM run	−0.85	48.6 ± 5.8	13.7 ± 1.5

[a] Values are means ± SD when available. Values in parentheses are ranges.
[b] TM = treadmill.
[c] Predicted VO_2max; otherwise oxygen uptake was collected directly.

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Muscular Strength and Muscular Endurance: Combining the Concepts

Muscular strength is the ability of a muscle group to exert a maximal force in a single voluntary effort. An example is lifting as much weight as possible one time. Absolute muscular endurance is the ability of a muscle group to repeat high intensity, submaximal contractions with a fixed load. An example is repeatedly lifting and lowering 10 kg with the arms. Relative muscular endurance is the ability of a muscle group to repeat high intensity, submaximal contractions at a specific percentage of the maximal strength. An example is repeatedly lifting and lowering 50% of the individual's maximal strength.

Studies examining the relationship between absolute muscular endurance and muscle strength[18-21] showed correlations ranging from 0.76 to 0.95. This means that individuals with high muscle strength tend to have high absolute muscular endurance. On the other hand, studies examining the relationship between relative muscular endurance and muscle strength[19,20,22-25] showed correlations ranging from −0.03 to −0.60. Thus, strong individuals are able to maintain a smaller proportion of their relative strength.

In a military environment it is the absolute muscular endurance that is important. Typical loads handled by soldiers include artillery shells, sand bags, crates, and weapons. The weights of these loads stay the same regardless of the individual soldier's strength. Stronger soldiers will have a greater capacity for the high intensity, short-term efforts required to lift and carry these loads. Thus, for military purposes it is possible to combine the concepts of muscular strength and endurance since they are highly related on an absolute basis. The term "muscular strength/endurance" is appropriate.

Push-ups, Sit-ups, and Pull-ups: Measures of Muscular Strength/Endurance

Factor analysis is the statistical technique most used to study the relationship between APFT test items and physical fitness. This technique attempts to identify the "components" of "physical fitness" and find test items that best measure these components. In a typical study many subjects perform a battery of tests assumed to be related to the various components of physical fitness. Correlation coefficients are calculated among the tests. Tests that group together with high intercorrelations are assumed to have some common fitness requirements that are called a "factor." The intercorrelated tests are then averaged and the scores on the individual test items are correlated with this average score. The resulting number is called a "factor loading." The factor loading quantifies the magnitude of the relationship between the test item and the general factor.[26]

In seven studies, factor analytic solutions were performed comparing the push-up, sit-up, pull-up, and various modifications of these tests. Shown in Table 3 are the factor loadings and the names given to the various factors. There were a number of difficulties in relating these studies to the APFT. First, few investigations provided details on test administration. Useful information that was often lacking included 1) time allowed to perform the test, 2) body position during the test, and 3) criteria for a correct repetition. In studies that did provide this information the tests were not performed in the same manner as on the APFT. Another problem was that the studies differed in the number and types of tests administered. This affected the size of the factor loadings. A final difficulty was that there were no studies in which females had been tested on push-ups or pull-ups. For these reasons each study is reviewed individually below.

Fleishman[26] administered 30 tests to 201 Navy recruits in their sixth week of basic training. The recruits performed as many push-ups as possible with a maximum of two seconds allowed between repetitions. Recruits also performed straight leg sit-ups with hands behind the neck and legs held down (30 seconds). Fleishman[26] identified four major strength factors: dynamic strength, static strength, explosive strength, and trunk strength.

Baumgartner and Zuidema[27,28] used test procedures similar to those of Fleishman.[26] They hypothesized that the domain of physical fitness consisted of four factors: upper body strength and endurance, leg strength and endurance, trunk strength

TABLE 3

FACTOR LOADINGS IN VARIOUS STUDIES

	Fleishman[26]		Baumgartner & Zuidema[27,28]						McCloy[29]	Liba[30]	Larson[31]	Philips[32]	
			Upper Body Stgh & Endr				Trunk Stgh & Endr						
			Study 1[27]		Study 2[28]		Study 1[27]						
	Dynamic Stgh M	Trunk Stgh M	M	F	M	F	M	F	Muscular Endr M	Body Weight Against Gravity F	Dynamic Stgh M	General Stgh F	Abdominal Stgh F
Push-ups	0.74		0.63		0.49				0.57		0.57		
Sit-ups	0.31	0.23	0.42				0.42	0.66	0.58			0.10	0.66
Pull-ups	0.81		0.52		0.75				0.42				
Chin-ups			0.56		0.75						0.79		
Bent Arm Hang	0.73									0.66			
Straight Arm Hang				0.58		0.72							
Modified Push-ups						0.60		0.55					
Modified Pull-ups				0.85									
Modified Chin-ups						0.63				0.56		0.03	0.32

Stgh = Strength; Endr = Endurance; M = Male; F = Female.

and endurance, and cardiorespiratory endurance. In their first study[27] they tested 283 college men and 336 women on 13 tests. In their second study[28] they tested 97 college men and 109 women. In their first study[27] they supported three of the hypothesized factors and in the second study[28] they supported all four. The tests given to men and women differed.

The remainder of the studies in Table 3 did not provide details on testing methods. McCloy[29] administered a 12-item test to 400 soldiers involved in "rather strenuous physical training for about 6 months." He identified four factors: cardiorespiratory endurance, speed of contraction, muscular endurance, and mesomorphy. Larson[31] gave a 23-item test battery to 160 male college freshmen. He found two distinct factors which he termed dynamic strength and static strength. Liba[30] tested 52 college women on 29 tests. She proposed a number of factors that included projecting the body, projecting objects, and holding, pushing, or pulling the body weight against gravity. Phillips[32] administered 26 tests to 200 college women. She identified four factors: general strength, abdominal strength, speed and an unknown factor.

Conclusions

The two-mile run is a valid measure of aerobic capacity for both males and females because it is highly correlated with VO_2max. Military tasks require absolute rather than relative muscular endurance. Because there is a close relationship between muscle strength and absolute muscular endurance, it is not necessary to evaluate these two components of fitness in separate tests. Most factor-analytic studies involving push-ups and sit-ups do not provide details on test administration. This makes it difficult to relate these studies to the standardized APFT push-ups and sit-ups. Data that are available suggest that push-ups and sit-ups are acceptable measures of muscular strength/endurance for males: they demonstrate moderate to high loadings on factors related to muscular strength/endurance. For females, sit-ups have moderate factor loadings, but no study has evaluated push-ups. Pull-ups (or variations of this test) demonstrated moderate to high loadings on muscle strength/endurance factors. Adoption of pull-ups as an APFT test item would require many units to obtain special equipment. Further research should be performed on fitness tests that include push-ups and sit-ups as administered on the APFT.

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References

1. Henson RG: APFT. Soldier Support Journal 56:April/June, 1987
2. Headquarters, Department of the Army: Physical Fitness Training. Field Manual 21-20. Washington DC, Department of the Army, pp 11-6–11-9, 1985
3. Heyward VH: Designs for Fitness. Minneapolis, Burgess Publishing Co, 1984, pp 4–5
4. Sharkey BJ: Physiology of Fitness. Champaign, IL, Human Kinetics Publishers Inc, 1984, pp 2–4
5. McArdle WD, Katch FI, Katch VL: Exercise Physiology. Philadelphia, Lea and Febiger, 1981, pp 121–124, 167–185
6. Ribisl PM, Kachadorian WO: Maximal oxygen intake prediction in young and middle-aged males. J Sports Med Phys Fitness 9:17–22, 1969
7. Shaver LG: Maximal aerobic power and anaerobic work capacity prediction from various running performances of untrained college men. J Sports Med Phys Fitness 15:147–150, 1975
8. Wiley JF, Shaver LG: Prediction of maximal oxygen intake from running performances of untrained young men. Research Quarterly 43:89–93, 1972
9. Burke EJ: Validity of selected laboratory and field tests of physical working capacity. Research Quarterly 47:95–104, 1976
10. Leach DA: The Measurement of Cardio-respiratory Endurance and the Standard of Evaluation for Army Personnel in the 40–45 Age Category. Carlisle, PA, US Army-War College, Study Project, May 1983
11. Cooper H: A means of assessing maximal oxygen intake. JAMA 203:135–138, 1968
12. Wyndham CH, Strydom NB, Van Graan CH, et al: Walk or jog for health. II. Estimating the maximal aerobic capacity for exercise. S Afr Med J 45:53–57, 1971
13. Johnson DJ, Oliver RA, Terry JW: Regression equation for prediction of performance in the twelve minute run-walk test. J Sports Med Phys Fitness 19:165–170, 1979
14. Harrison MH, Bruce DL, Brown GA, et al: A comparison on some indirect methods for predicting maximal oxygen uptake. Aviat Space Environ Med 51:1128–1133, 1980
15. Rasch RJ, Wilson ID: The correlation of selected laboratory tests of physical fitness with military endurance. Milit Med 129:256–258, 1964
16. Custer SJ, Chaloupka EC: Relationship between predicted maximal oxygen consumption and running performance of college females. Research Quarterly 48:47–50, 1977
17. Mello R, Murphy M, Vogel J: Relationship between a two mile run for time and maximal oxygen uptake. J Appl Sports Sci 2:9–12, 1988
18. Eckert H, Day JO: Relationship between strength and workload in push ups. Research Quarterly 38:380–383, 1967
19. Tuttle W, Janney C, Salzano J: Relation of maximal back and leg strength to back and leg endurance. Research Quarterly 26:96–106, 1955
20. Tuttle WW, Janney CD, Thompson CW: Relation of maximum grip strength to grip strength endurance. J Appl Physiol 2:663–670, 1950
21. Martens R, Sharkey BJ: Relationship of phasic and static strength and endurance. Research Quarterly 37:435–436, 1966
22. Clarke HH: Muscular Strength and Endurance in Man. Englewood Cliffs, NJ, Prentice Hall, 1966, pp 38–75
23. Caldwell LS: The Load-Endurance Relationship for a Static Manual Response. Ft Knox, KY, US Army Medical Research Laboratory, Technical Report No AMRL573, 1963
24. Caldwell LS: Relative muscle loading and endurance. J Eng Psychol 2:155–161, 1963
25. Carlson BR, McCraw LW: Isometric strength and relative muscular endurance. Research Quarterly 42:244–250, 1971
26. Fleishman EA: The Structure and Measurement of Physical Fitness. Englewood Cliffs, NJ, Prentice Hall, 1964, pp 38–75
27. Baumgartner TA, Zuidema MA: Factor analysis of physical fitness tests. Research Quarterly 43:443–450, 1972
28. Zuidema MA, Baumgartner TA: Second factor analysis study of physical fitness tests. Research Quarterly 45:247–256, 1974
29. McCloy CH: A factor analysis of tests of endurance. Research Quarterly 27:213–216, 1956
30. Liba MR: Factor analysis of strength variables. Research Quarterly 38:649–662, 1967
31. Larson LA: A factor and validity analysis of strength variables and tests with a test combination of chinning, dipping and vertical jump. Research Quarterly 12:82–96, 1941
32. Phillips M: Study of a series of physical education tests by factor analysis. Research Quarterly 20(1):60–71, 1949