Behind the Army Physical Fitness Test

Introduction

The Army Physical Fitness Test is a physical fitness test used by the Army to determine a soldier's muscular strength and cardiovascular endurance. The APFT consists of three events: two minutes of push-ups, two minutes of sit-ups and a two-mile run. The amount of points earned in each event is based on age and gender as seen in Appendix A. Our group sought to find a relationship between a person's APFT score and nine variables through a survey of the United States Military Academy Corps of Cadets to determine which of these variables are the best predictors of a person's APFT score. As cadets and members of an organization that conducts physical fitness tests regularly, we thought it would be interesting to see which of these factors are most important in predicting a person's APFT score. While a sample such as ours (only West Point cadets and variables some specific to cadets) cannot be used to generalize our findings to the Army at large, it is still interesting to see which factors have the largest impact on a cadet's APFT score. We hypothesize that an individual's Indoor Obstacle Course Test (IOCT) grade will be the biggest predictor of their APFT score.

Any time an anonymous survey is used, the data presents problems in how individuals complete the survey. For our data specifically, we found several instances in which individuals did not complete the entire survey and data that was clearly incorrect or not possible. Despite this, we were able to develop an effective model that explains approximately 35.76% of the variation in the APFT scores. This model was developed using what we found to be the two most significant variables when predicting an individual's APFT score: IOCT grade and gender. Our results suggest that females typically score higher on the APFT and that those wanting to increase their APFT score should focus on performing well on the IOCT, a proxy for physical fitness.

Methodology

To develop a statistically significant model, a representative and random sample is necessary. To obtain this, we created an online survey and sent it out to our companies and clubs. This ensured that between three companies and at least one club, we would be obtaining data evenly distributed throughout the Corps. In our survey we asked cadets for their APFT score (our response variable) as well as their height, weight, gender, age, race/ethnicity, IOCT grade and whether they are a Division 1 athlete. The IOCT is physical test conducted by cadets at West Point as a measure of their functional fitness. The IOCT grade is on a 4.0 scale correlated with the time of completion of the test. Additionally, the grading scale is based on gender as well, for example, for a male and female cadet who both run the IOCT in 3 minutes, the male would receive a C (2.33) and the female would receive an A+ (4.33).

Of our total 127 responses, only 114 were usable. This was because of several responses that were not completely filled out and some that were clearly inaccurate. Of the 13 responses that were removed from the data, most were due to people that did not fill out the IOCT grade of the survey; we suspect that this is due to freshmen taking the survey that have not yet taken Military Movement. After all invalid responses were removed from the data, we converted the IOCT grade from a letter grade scale to a 4.0 scale so that it could be easily interpreted in R Studio. Additionally, after the data was uploaded into R Studio variables such as gender, Corps Squad athlete and each category of race/ethnicity were converted into (1,0) binary variables. For all responses that had more than one race/ethnicity, "white" (white was consistently the second race) was removed so that the data only showed one of the other four categories. For responses with more than two race/ethnicity categories, the third category was removed at random. After all the adjustments were made to the variables, we were left with 11 variables to test (the original 9 with race/ethnicity broken into 4 binary variables: Asian, Black or African American, Native American, and Hispanic or Latino).

We then made models comparing APFT scores to each of the 11 variables. After our initial 6

models, we determined that IOCT grade, gender, and weight were the most significant variables based on their p-values. We then developed another model, testing the relationship between the APFT and the combination of these three variables, with an R-squared value of 0.3701 and an adjusted R-squared value of 0.3526. Because weight was the least significant variable of the three used in this model, we developed another model using only IOCT and gender. This final model was our best fitting model to the data with an R-squared value of 0.3692 and an adjusted R-squared value of 0.3576. While the R-squared value of the previous model is higher than that of the final model, having fewer variables in the final model made its adjusted R-squared value higher than that of the previous.

Our group made several assumptions to correctly interpret and apply our chosen model. We assume that the data gathered is independent and has a linear relationship with APFT scores. While within the chosen variables some may be confounding (such as height and weight), we tested these variables against the APFT scores together to mitigate this. Additionally, neither height nor weight were significant enough to be added to the final model.

Results/Discussion

This equation for our chosen model is.

$$\hat{y} = 260.226 + 16.090x_1 - 19.874x_2$$

The following table identifies and describes the variables used in the regression model as well as all the variables used in the development of the model.

Table 1 - Variables Used in Regression Model

Name	Variable	Unit	Max/Min Values
APFT score	y	Numeric	0/375
IOCT grade	x_1	4.0 GPA scale	0/4.33
Gender	x_2	Binary	0(Female)/ 1(Male)
Height	x_3	Numeric (inches)	55/84
Weight	x_4	Numeric (pounds)	90/300
Division 1 Athlete	x_5	Binary	0(No)/1(Yes)
Asian	x_6	Binary	0(No)/1(Yes)
Black or African American	x_7	Binary	0(No)/1(Yes)
Native American	x_8	Binary	0(No)/1(Yes)
Hispanic or Latino	x_9	Binary	0(No)/1(Yes)
Age	x_{10}	Numeric (years)	17/27

The y-hat value is the predicted value of the APFT score. For this model, the base score represents a female ($x_2 = 0$) that has failed the IOCT ($x_1 = 0$) with a predicted APFT score of 260. The coefficients of the variables indicate how much the predicted APFT score will change with each unit increase in that variable. Given that gender is binary, our model indicates that males ($x_1 = 1$) in general score approximately 20 points lower on the APFT. Additionally, the coefficient for x_1 indicates that for every letter grade increase on the IOCT, the predicted APFT score will increase by approximately 16 points.

In assessing the strength of the relationship between the variables and the APFT score, we observed the adjusted R-squared value to address the fit of the model while accounting for the number of variables in the model. Seeing that the model has an adjusted R-squared value of 0.3576, the model accounts for 35.76% of the variance in APFT scores. The greatest predictor of APFT score is IOCT grade with a p-value of 7.3x10^-11. This p-value shows strong evidence against the null hypothesis that the slope is equal to zero.

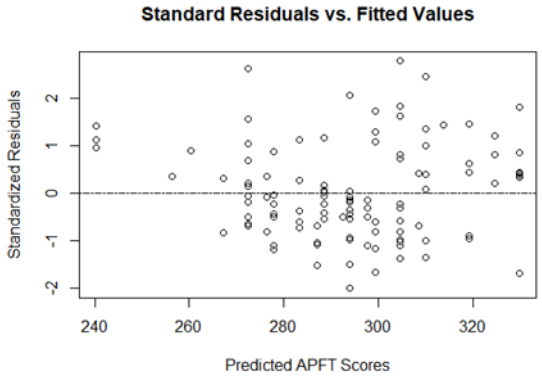

Figure 1

When examining the validity of our results, we tested for its linearity, independence, normally distributed residuals, and constant variance. To test for constant variance, we examine Figure 1. Since there is a random scatter above and below zero and most residuals lie in between 2 and -2 standard deviations, we can say that the residuals have relatively constant variance.

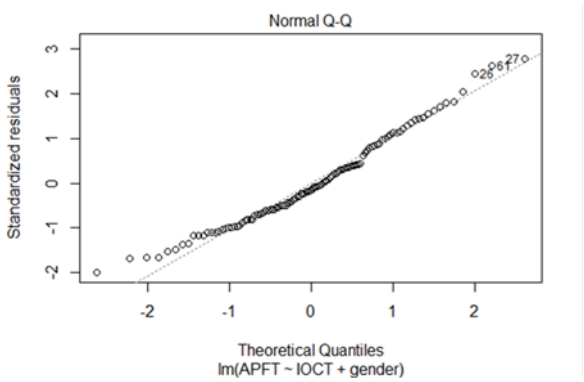

Figure 2

When assessing the normality of the residuals, we use a Q-Q plot. Ours, seen above in Figure 2, has a slightly light left tail and heavy right tail. Most of our points between 2 standard deviations are along the Q-Q line. Figure 3 conveys the accuracy of predicted APFT scores and their corresponding true values. Generally, our predicted values and actual values trend with the 45-degree line, indicating reasonable predictions.

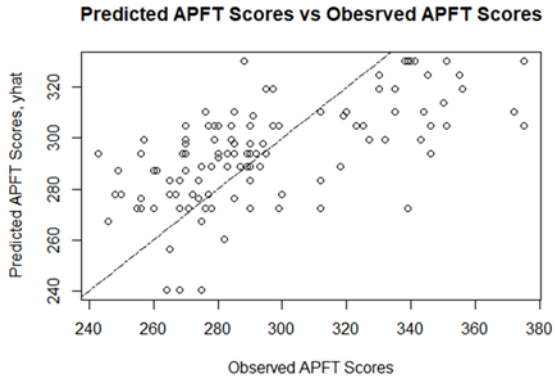

Figure 3

If the two gender scales were properly standardized, gender would not be relevant to our model. Based our data, however, females score approximately 20 points higher than males.

Conclusion

Our model concludes that IOCT grade and gender have the largest effect on predicting APFT score. Because of this, we can make two inferences. The first inference is that those who want to do better on the APFT should work on improving their IOCT grade because a high IOCT is strongly correlated to a higher APFT score. The second inference is that females generally score higher on the APFT than males. This does not imply that to do well on the APFT you must be a female, but it does show that if females generally score 20 points higher than males that the grading scales may be skewed and need adjustment.

Because both the APFT and IOCT are tests of physical ability, it makes sense that people that do well on one will most likely do well on the other. This leads us to conclude that the most important take away from our model is the fact that females are scoring higher than males. The grading scale of the APFT is supposed to ensure that males and females APFT scores both follow normal distributions and that those normal distributions line up with each other. However, our model shows that the female distribution falls about 20 points to the right of the male distribution. This led us to conduct a two-sample hypothesis test to determine whether the mean AFPT for score for females is higher than that of males. The results of this conclude that the average female score is 19.5 points higher than the average male score with a p-value of 0.003, conveying the significance of this difference in APFT mean scores. Thus, we conclude that the APFT grading scale needs to be adjusted for females or males in a way that will bring the two distributions back together.

Appendix A – Army Physical Fitness Test Grading Scales

SIT-UP STANDARDS					
AGE GROUP	17-21	22-26	27-31	32-36	AGE GROUP
REPS	M/F	M/F	M/F	M/F	REPS
82			100		82
81			99		81
80		100	98		80
79		99	97		79
78	100	97	96		78
77	98	96	95		77
76	97	95	94	100	76
75	95	93	92	99	75
74	94	92	91	98	74
73	92	91	90	96	73
72	90	89	89	95	72
71	89	88	88	94	71
70	87	87	87	93	70
69	86	85	86	92	69
68	84	84	85	91	68
67	82	83	84	89	67
66	81	81	83	88	66
65	79	80	82	87	65
64	78	79	81	86	64
63	76	77	79	85	63
62	74	76	78	84	62
61	73	75	77	82	61
60	71	73	76	81	60
59	70	72	75	80	59
58	68	71	74	79	58
57	66	69	73	78	57
56	65	68	72	76	56
55	63	67	71	75	55
54	62	65	70	74	54
53	***60***	64	69	73	53
52	58	63	68	72	52
51	57	61	66	71	51
50	55	***60***	65	69	50
49	54	59	64	68	49
48	52	57	63	67	48
47	***50***	56	62	66	47
46		55	61	65	46
45		53	***60***	64	45
44		52	59	62	44
43		***50***	58	61	43
42			57	***60***	42
41			56	59	41
40			55	58	40
39			54	56	39
38			52	55	38
37			51	54	37
36			***50***	53	36
35				52	35
REPS	M/F	M/F	M/F	M/F	REPS
AGE GROUP	17-21	22-26	27-31	32-36	AGE GROUP

Appendix A (Continued)

PUSH-UP STANDARDS									
AGE GROUP	17-21		22-26		27-31		32-36		AGE GROUP
REPS	M	F	M	F	M	F	M	F	REPS
77					100				77
76					99				76
75			100		98		100		75
74			99		97		99		74
73			98		96		98		73
72			97		95		97		72
71	100		95		94		96		71
70	99		94		93		95		70
69	97		93		92		94		69
68	96		92		91		93		68
67	94		91		89		92		67
66	93		90		88		91		66
65	92		89		87		90		65
64	90		87		86		89		64
63	89		86		85		88		63
62	88		85		84		87		62
61	86		84		83		86		61
60	85		83		82		85		60
59	83		82		81		84		59
58	82		81		80		83		58
57	81		79		79		82		57
56	79		78		78		81		56
55	78		77		77		79		55
54	77		76		76		78		54
53	75		75		75		77		53
52	74		74		74		76		52
51	72		73		73		75		51
50	71		71		72	100	74		50
49	70		70		71	99	73		49
48	86		69		69	98	72		48
47	67		68		68	96	71		47
46	66		67	100	67	95	70		46
45	64		66	99	66	94	69	100	45
44	63		65	97	65	93	68	99	44
43	61		63	96	64	82	67	97	43
42	***60***	100	62	94	63	90	66	96	42
41	59	96	61	93	62	89	65	95	41
40	57	97	***60***	92	61	88	64	93	40
39	56	95	59	90	***60***	87	63	92	39
38	54	93	58	89	59	85	62	91	38
37	53	91	57	88	58	84	61	89	37
36	52	90	55	86	57	83	***60***	88	36
35	***50***	88	54	85	56	82	59	87	35
34		86	53	83	55	81	58	85	34
33		84	52	82	54	79	57	84	33
32		83	51	81	53	78	56	83	32
31		81	***50***	79	52	77	55	81	31
30		79		78	***50***	76	54	80	30
29		77		77		75	53	79	29
28		76		75		73	52	77	28
27		74		74		72	51	76	27
26		72		72		71	***50***	75	26
25		70		71		70		73	25
24		69		70		68		72	24
23		67		68		67		71	23
22		65		67		66		69	22
21		63		66		65		68	21
20		62		64		64		67	20
19		***60***		63		62		65	19
18		58		61		61		64	18
17		57		***60***		***60***		63	17
16		55		59		59		61	16
15		53		57		58		***60***	15
AGE GROUP	17-21		22-26		27-31		32-36		AGE GROUP
REPS	M	F	M	F	M	F	M	F	REPS

Appendix A (continued)

2-MILE RUN STANDARDS

AGE GROUP	17-21		22-26		27-31		32-36		AGE GROUP
TIME	M	F	M	F	M	F	M	F	TIME
12:54									12:54
13:00	100		100						13:00
13:06	99		99						13:06
13:12	97		98						13:12
13:18	96		97		100		100		13:18
13:24	94		96		99		99		13:24
13:30	93		94		98		98		13:30
13:36	92		93		97		97		13:36
13:42	80		92		96		96		13:42
13:48	89		91		95		95		13:48
13:54	88		90		94		95		13:54
14:00	86		89		92		94		14:00
14:06	85		88		91		93		14:06
14:12	83		87		90		92		14:12
14:18	82		86		89		91		14:18
14:24	81		84		88		90		14:24
14:30	79		83		87		89		14:30
14:36	78		82		86		88		14:36
14:42	77		81		85		87		14:42
14:48	75		80		84		86		14:48
14:54	74		79		83		85		14:54
15:00	72		78		82		85		15:00
15:06	71		77		81		84		15:06
15:12	70		76		79		83		15:12
15:18	68		74		78		82		15:18
15:24	67		73		77		81		15:24
15:30	66		72		76		80		15:30
15:36	64	100	71	100	75		79		15:36
15:42	63	99	70	99	74		78		15:42
15:48	61	98	69	98	73	100	77		15:48
15:54	***60***	96	64	97	72	99	76	100	15:54
16:00	59	95	67	96	71	98	75	99	16:00
16:06	57	94	66	95	70	97	75	99	16:06
16:12	56	93	64	94	69	97	74	98	16:12
16:18	54	92	63	93	68	96	73	97	16:18
16:24	53	90	62	92	66	95	72	97	16:24
16:30	52	89	61	91	65	94	71	96	16:30
16:36	***50***	88	***60***	90	64	93	70	95	16:36
16:42		87	59	89	63	92	69	94	16:42
16:48		84	58	88	62	91	68	94	16:48
16:54		83	57	87	61	91	67	93	16:54
17:00		82	56	86	***60***	90	66	92	17:00
17:06		81	54	85	59	89	65	92	17:06
17:12		79	53	84	58	88	65	91	17:12
17:18		78	52	83	57	87	64	90	17:18
17:24		77	51	82	56	86	63	90	17:24
17:30		76	***50***	81	55	86	62	89	17:30
17:36		75		80	54	85	61	88	17:36
17:42		73		79	53	84	***60***	88	17:42
17:48		72		78	52	83	59	87	17:48
17:54		71		77	51	82	58	86	17:54
18:00		70		76	***50***	81	57	86	18:00
18:06		68		75		80	56	85	18:06
18:12		67		74		80	55	84	18:12
18:18		66		73		79	55	83	18:18
18:24		65		72		78	54	83	18:24
18:30		64		71		77	53	82	18:30
18:36		62		70		76	52	81	18:36
18:42		61		69		75	51	81	18:42
18:48		***60***		68		74	***50***	80	18:48
18:54		59		67		74		79	18:54
19:00		58		66		73		79	19:00
19:06		56		65		72		78	19:06
19:12		55		64		71		77	19:12
19:18		54		63		70		77	19:18
19:24		53		62		69		76	19:24
19:30		52		61		69		75	19:30
19:36		***50***		***60***		68		74	19:36
19:42				59		67		74	19:42
19:48				58		66		73	19:48
19:54				57		65		72	19:54
20:00				56		64		72	20:00
20:06				55		63		71	20:06
20:12				54		63		70	20:12
20:18				52		62		70	20:18
20:24				51		61		69	20:24
20:30				***50***		***60***		68	20:30
20:36						59		68	20:36
20:42						58		67	20:42
20:48						57		66	20:48
20:54						57		66	20:54
21:00						56		65	21:00
21:06						55		64	21:06
21:18						54		63	21:18
21:24						53		63	21:24
21:30						52		62	21:30
21:36						51		61	21:36
21:42						51		61	21:42
21:48						***50***		***60***	21:48
21:54								59	21:54
22:00								59	22:00
22:06								58	22:06
22:12								57	22:12
22:18								57	22:18
22:24								56	22:24
22:30								55	22:30
22:36								54	22:36
22:42								53	22:42
22:48								52	22:48
22:54								51	22:54
23:00								51	23:00
23:06								***50***	23:06
TIME	M	F	M	F	M	F	M	F	TIME
AGE GROUP	17-21		22-26		27-31		32-36		AGE GROUP