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Physical fitness characteristics of active duty US Air Force members with HIV infection

Asha De, MD[a], Xiaohe Xu, PhD[b], James White, BS[b], Thankam S. Sunil, PhD, MPS[b], Jason F. Okulicz, MD[c,*]

Abstract

Human immunodeficiency virus (HIV) infection is associated with reduced muscle mass and adverse metabolic effects. We evaluated the impact of HIV infection on longitudinal exercise performance in US Air Force (USAF) members with HIV infection.

USAF members perform standardized fitness assessments every 6 to 12 months with a composite score comprised of abdominal circumference, push-ups, sit-ups, and 1.5-mile run. Fitness tests between 2004 and 2014 for male USAF members with HIV infection (n = 172) were compared with male HIV-negative controls (~10 per case; n = 1636) matched by age and rank category at service entry.

Fitness tests for cases (n = 1821) were divided into 2 groups, before (pre-HIV) and after (post-HIV) diagnosis, and compared with control fitness assessments (n = 30,443) by paired *t* tests. Random-effects regression analyses were also performed to compare fitness components.

Mean composite scores for cases were higher post-HIV (87.06 ± 9.10) compared with pre-HIV (84.92 ± 8.36; *P* = 0.004) and did not differ from respective controls. Compared with pre-HIV, mean push-up (51.50 ± 9.67 vs 50.35 ± 11.18; *P* = 0.018) and sit-up (51.66 ± 7.81 vs 50.57 ± 9.19; *P* < 0.001) counts improved post-HIV, whereas run times were similar (11:53 ± 1:42 vs 11:51 ± 2:05; *P* = 0.056). Regression analyses demonstrated that cases had significantly lower predicted abdominal circumference and push-up counts over time compared with controls, regardless of pre-HIV or post-HIV status (*P* < 0.05 for all).

Although functional limitations may occur in the setting of HIV infection, vigorous exercise performance can be both preserved and improved in HIV-infected individuals at a level comparable with HIV-uninfected persons.

Abbreviations: AIDS = acquired immune deficiency syndrome, ART = antiretroviral therapy, BMI = body mass index, HIV = human immunodeficiency virus, SAMMC = San Antonio Military Medical Center, USAF = United States Air Force, VL = viral load.

Keywords: AIDS, exercise, fitness, HIV, muscle strength

1. Introduction

Life expectancy for human immunodeficiency virus (HIV) infection has significantly improved in the 3 decades after recognition of the first clinical cases of acquired immune deficiency syndrome (AIDS).[1,2] However, HIV infection remains associated with increased morbidity and impaired physical performance. Comorbid conditions are also increased in HIV-infected persons compared with those of similar age in the HIV-uninfected population.[3] In particular, HIV infection is associated with increased risk of cardiovascular disease and metabolic disturbances, including diabetes and metabolic syndrome, which can further add to physical dysfunction associated with HIV infection.[4–6]

There are a variety of mechanisms by which HIV infection can lead to impairments in physical function. For example, a reduction in lean muscle mass can be observed in HIV infection, which is associated with faster HIV progression, morbidity, and mortality.[7–9] Fat redistribution is also well-described, with loss of subcutaneous adipose tissue and gain of visceral adipose tissue, the latter which has been associated with increased cardiovascular risk and an increased 5-year, all-cause mortality in HIV-infected persons.[10–13] Advanced HIV disease is often marked by impairments in both muscle strength and aerobic function.[7,14] The development of AIDS or opportunistic infections can result in a decline in physical performance due to factors such as fatigue, anorexia, dysphagia, malabsorption, muscle atrophy, and decreased habitual physical activity.[15,16] Finally, HIV-associated weight loss and wasting remains common in some patients even in the modern era of antiretroviral therapy (ART).[17]

The majority of exercise and physical performance studies in the literature have been conducted in older HIV-infected persons. In these studies, individuals with HIV infection demonstrated impairments in mild to moderate physical activity, such as reduced gait speed and 6-minute walk times, and also greater overall difficulty with other physical activities.[18,19] In contrast, studies evaluating the impact of HIV infection on vigorous

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[a] Internal Medicine Residency, San Antonio Military Medical Center, Fort Sam Houston, [b] University of Texas San Antonio, Department of Sociology, San Antonio, [c] Infectious Disease Service, San Antonio Military Medical Center, Fort Sam Houston, Texas, USA.

[*] Correspondence: Jason F. Okulicz, San Antonio Military Medical Center, 3551 Roger Brooke Drive, Fort Sam Houston, TX 78234, USA (e-mail: jason.f.okulicz.mil@mail.mil).

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exercise are limited and typically involved the implementation of short-term, structured exercise programs without longitudinal follow-up.[20–22] There are no published longitudinal studies of physical fitness that include assessments of both aerobic performance and muscle strength in a population with HIV infection. The US Air Force (USAF) conducts standardized fitness assessments for all active duty members every 6 to 12 months, which evaluates body composition, muscle strength, and aerobic performance. To better understand the impact of HIV on physical performance with vigorous exercise, we evaluated longitudinal fitness characteristics for active duty USAF members with and without HIV infection.

2. Methods

USAF members have mandatory HIV testing every 2 years, or more frequently in the setting of deployment or if clinically indicated.[23] All USAF members diagnosed with HIV infection have mandatory clinical evaluations at the San Antonio Military Medical Center (SAMMC) every 6 to 12 months. The USAF manages all healthcare, travel, and lodging costs. Clinical visits include HIV disease staging, laboratory evaluation, immunizations, and HIV education. We conducted a retrospective study using physical fitness tests and data from electronic medical records collected from active duty USAF members diagnosed with HIV infection between January 1, 2004 and August 31, 2014. This retrospective study was approved by the SAMMC Institutional Review Board.

Since 2004, the standardized USAF fitness test is comprised of 4 components. Body composition is determined by measurement of abdominal circumference. Strength is assessed by the number of push-ups and sit-ups performed in 1 minute and aerobic conditioning is evaluated by a timed 1.5-mile run. A composite score (maximum = 100) is calculated by summation of the component scores for abdominal circumference (maximum score = 20), sit-ups (maximum score = 10), push-ups (maximum score = 10), and 1.5-mile run (maximum score = 60). Performance scores for each component are based on decade of age, sex, and amount of repetitions or elapsed time (available at http://www.afpc.af.mil/affitnessprogram/charts.asp). A passing composite score is ≥75 and an excellent score is ≥90. Body mass index (BMI) is also calculated, but not included in the composite score. USAF members take the standardized fitness test upon entry into military service. The frequency of subsequent fitness assessments depends upon the composite score of the most recent fitness test, with passing scores requiring testing at 6 months and excellent scores testing at 12 months. Members with physical injuries, pregnancy, or other conditions that limit the ability to take the fitness assessment are either deferred from testing or take only certain components of the test.

2.1. Study population

Inclusion criteria were male active duty USAF members with HIV infection and fitness tests between January 1, 2004 and August 31, 2014 (n = 172). Exclusion criteria were USAF members with HIV infection not on continuous active duty and females (due to small numbers). The control group was comprised of HIV-uninfected active duty USAF males matched by age and rank status (officer or enlisted) with approximately 10 controls assigned for each case (n = 1636). Composite fitness test scores, and also component scores for abdominal circumference, push-ups, sit-ups, and 1.5-mile run, were assessed. BMI was also analyzed. Tests that did not include all components of the fitness assessment were excluded for both cases and controls.

2.2. Data management

Fitness tests over time for HIV-infected cases were divided into 2 categories according to the date of HIV diagnosis. The pre-HIV time period includes all fitness tests available until the date of last known HIV-negative screening test. The post-HIV period includes all fitness assessments that occurred after the date of first positive HIV test. Fitness tests for the control group were also divided into 2 categories based on the corresponding test dates matched to the pre-HIV and post-HIV periods for cases. To evaluate the potential impact of HIV infection on physical performance, fitness assessments for cases were compared pre-HIV and post-HIV. Post-HIV cases were also analyzed by categories of CD4 cell count and viral load (VL) at or before the time of fitness tests. Cases were also compared with matched controls of the same age at the time of testing.

2.3. Statistical analysis

Characteristics were compared using simple bivariate tests. Based on Hausman test results, random-effects regression models were used to compare body composition and fitness performance with robust standard errors utilized to control for heteroscedasticity. Cross-sectional regression models were also used to compare the most recent test pre-HIV diagnosis and first test post-HIV diagnosis for cases. Analyses were performed using Stata 13, and P values <0.05 were considered statistically significant.

3. Results

A total of 172 cases with HIV infection and 1636 HIV-uninfected controls were included and contributed 1821 and 30,443 fitness tests, respectively (Table 1). For cases, the mean age at entry into military service entry was 21.2 (±3.6) years and the majority were enlisted members. The mean time from the last documented HIV-negative test to first positive test was 17.8 (±12.4) months, and the mean age at HIV diagnosis was 28.1 (±6.2) years. Among cases, the mean CD4 count and VL at HIV diagnosis was 575 (±269) cells/μL and 3.68 (±1.30) $\log_{10}$copies/mL, respectively.

Cases had a mean of 3.59 (±2.33) tests before HIV diagnosis and 7.44 (±3.71) tests after HIV diagnosis ($P<0.001$). A total of 47 (27.3%) cases did not have fitness tests available before HIV diagnosis because these fitness assessments occurred before the current testing format was implemented in 2004. The largest proportion of pre-HIV tests occurred in those 18–29 years of age (75.4%), whereas post-HIV tests were similarly distributed between the 18 to 29 (46.8%) and 30 to 39 (42.9%) age categories.

3.1. Pre-HIV versus post-HIV cases

Evaluation of fitness tests for cases before and after HIV infection showed higher mean composite scores post-HIV (87.06 ± 9.10) compared with pre-HIV (84.92 ± 8.36; $P=0.004$). Mean post-HIV scores were also better than pre-HIV for the components of push-up count (51.50 ± 9.67 vs 50.35 ± 11.18; $P=0.018$) and sit-up count (51.66 ± 7.81 vs 50.57 ± 9.19; $P<0.001$), whereas 1.5-mile run times were similar (11:53 ± 1:42 vs 11:51 ± 2:05; $P=0.056$). Abdominal circumference was no different pre-HIV (32.52 ± 3.30 inches) compared with post-HIV (32.41 ± 3.15

Table 1

Fitness test results for pre-HIV and post-HIV cases compared with controls.

Characteristic	Pre-HIV cases	Post-HIV cases	Pre-HIV vs post-HIV (*P* value)/effect size	Pre-HIV controls	Pre-HIV cases vs controls (*P* value)/effect size	Post-HIV controls	Post-HIV cases vs controls (*P* value)/effect size
Number of persons	125	172	—	1631	—	1636	—
Total number of fitness tests	574	1247	—	14,001	—	16,442	—
Fitness tests per person	3.59 (2.33)	7.44 (3.71)	<0.001/1.15	28.62 (6.18)	<0.001/4.12	6.10 (3.70)	<0.001/0.36
Age at tests, y	26.62 (6.50)	30.79 (6.68)	<0.001/0.62	29.06 (6.35)	<0.001/0.38	29.06 (6.35)	<0.001/0.27
18–29 (reference)	433 (75.40)	584 (46.80)	—	8368 (59.80)	—	9406 (57.21)	—
30–39	116 (20.20)	535 (42.90)	—	4892 (34.90)	—	5984 (36.39)	—
40+	25 (4.40)	128 (10.30)	—	741 (5.30)	—	1052 (6.40)	—
Military rank							
Enlisted (reference)	524 (91.30)	1124 (90.10)	—	12,135 (86.70)	—	14,239 (86.60)	—
Officer	50 (8.7)	123 (9.9)	—	1866 (13.30)	—	2203 (13.40)	—
Body composition							
Body mass index	24.95 (3.41)	25.21 (3.33)	<0.001/0.08	26.18 (3.36)	<0.001/0.37	26.27 (3.35)	<0.001/0.32
Underweight	1 (0.20)	24 (1.90)	—	56 (0.40)	—	69 (0.42)	—
Normal (reference)	335 (58.40)	610 (48.90)	—	5207 (37.20)	—	5912 (35.96)	—
Overweight	186 (32.40)	511 (41.00)	—	6999 (49.90)	—	8343 (50.74)	—
Obese	52 (9.10)	102 (8.20)	—	1739 (12.40)	—	2118 (12.98)	—
Abdominal circumference (inches)	32.52 (3.30)	32.41 (3.15)	0.608/0.03	33.27 (3.03)	0.004/0.25	33.27 (3.00)	<0.001/0.29
Fitness performance							
Composite Score	84.92 (8.36)	87.06 (9.10)	0.004/0.24	85.43 (9.18)	0.468/0.06	85.73 (9.55)	0.050/0.14
≥90 (excellent)	163 (28.40)	527 (42.26)	<0.001	4574 (32.67)	0.011	5735 (34.88)	<0.001
75–89 (pass)	360 (62.72)	651 (52.21)	—	8544 (61.02)	—	9720 (59.12)	—
<75 (fail)	51 (8.89)	69 (5.53)	—	883 (6.31)	—	987 (6.00)	—
Sit-up count	50.57 (9.19)	51.66 (7.81)	<0.001/0.13	52.32 (7.98)	0.037/0.22	52.60 (7.80)	0.116/0.12
Push-up count	50.35 (11.18)	51.50 (9.67)	0.018/0.11	53.04 (10.50)	0.001/0.26	53.30 (10.36)	0.002/0.17
1.5-mile run, min:s	11:51 (2:05)	11:53 (1:42)	0.056/0.01	11:59 (1:56)	0.323/0.05	12:01 (2:11)	0.336/0.23

Data expressed as mean (standard deviation) number of tests or number (%).
HIV=human immunodeficiency virus.

inches; $P=0.608$). There was a small increase in BMI post-HIV (25.21 ± 3.33) compared with pre-HIV (24.95 ± 3.41; $P<0.001$), and the largest proportion of assessments had normal BMI (48.9% vs 58.4%, respectively).

3.2. Cases versus controls

Mean composite scores were similar for pre-HIV cases (84.92 ± 8.36) and controls (85.43 ± 9.18; $P=0.468$). For mean component scores, push-up (53.04 ± 10.50 vs 50.35 ± 11.18; $P=0.001$) and sit-up (52.32 ± 7.98 vs 50.57 ± 9.19; $P=0.037$) counts were higher in the control group compared with the pre-HIV group, respectively, whereas run times were no different. Post-HIV mean composite scores were higher than controls (87.06 ± 9.10 vs 85.73 ± 9.55; $P=0.05$), with a greater proportion achieving "excellent" scores (42.3% vs 34.9%). The post-HIV group had significantly lower mean push-up counts compared with controls (51.5 ± 9.67 vs 53.3 ± 10.36; $P=0.002$). Both pre-HIV and post-HIV groups had significantly lower mean BMI and abdominal circumference values compared with their respective controls. Predicted scores by age for body composition (Fig. 1), and also the composite scores and individual components for muscle strength and aerobic performance (Fig. 2) are presented for cases and controls.

3.3. Regression modeling

Regression analyses of the most recent test at or before the last HIV-negative date and the first test after HIV diagnosis showed that USAF members with HIV infection had lower BMI and scored significantly lower on push-up counts than controls (Table 2). Furthermore, cases were 0.48 units lower post-HIV in the predicted abdominal circumference than controls ($P<0.01$). Longitudinal fitness outcome variables evaluated by random-effects regression models (Table 3) showed no significant differences in outcomes between cases pre-HIV and post-HIV, with the exception of abdominal circumference which was 0.33 units lower post-HIV ($P<0.05$) as indicated by the negative regression coefficient. Comparisons of cases and controls had several notable findings. Cases had a significantly lower predicted BMI and lower push-up counts over time than controls regardless of pre-HIV or post-HIV status, as the regression coefficients were uniformly negative and statistically significant at or below the $P<0.05$ level. The predicted abdominal circumference was also 0.55 units lower over time post-HIV compared with controls ($P<0.001$). Moreover, the odds of achieving an "excellent" composite score in fitness tests over time was 75.1% [(exp (0.56) = 1.75–1) × 100] higher for USAF members post-HIV than for uninfected controls.

The majority of post-HIV cases had relatively preserved CD4 counts at or before fitness tests, with 90.7% having CD4 counts ≥350 cells/μL. Although data for timing of ART initiation were not available, VL suppression (<50 copies/mL) was assessed as a surrogate for effective treatment, with 56.4% of cases having VL suppression at the time of fitness testing. Regression analyses of post-HIV cases with CD4 count ≥350 vs <350 cells/μL showed no difference in composite results, individual fitness test components, or BMI. However, analyses of VL ≥50 vs <50 copies/mL showed a reduction of 2.71 units and 1.14 units for composite ($P<0.001$) and "excellent" scores ($P<0.01$), respectively.

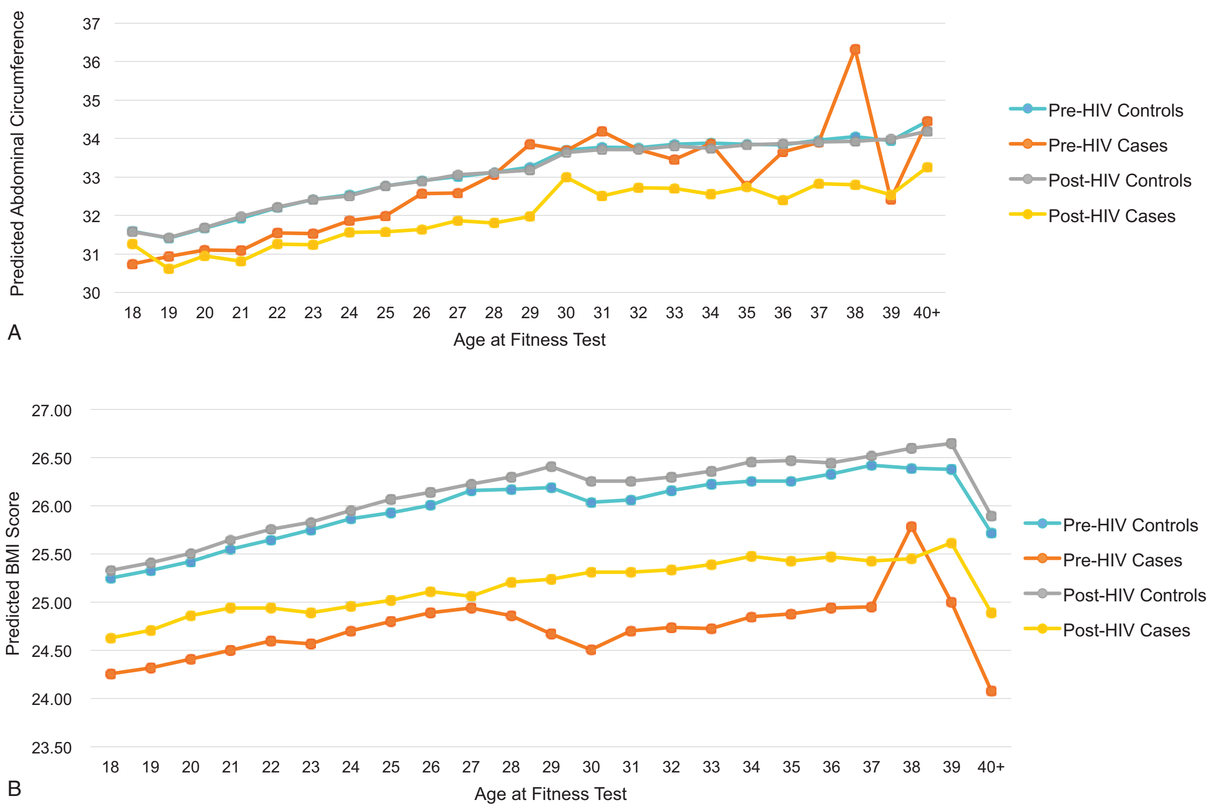

Figure 1. Adjusted body composition values by age and HIV status.

4. Discussion

This study analyzed service-mandated fitness tests to assess vigorous physical exercise performance in HIV-infected USAF members. Both the longitudinal and cross-sectional results demonstrate that during a 10-year span from 2004 to 2014, USAF members with HIV had similar composite test scores compared with HIV-uninfected controls. These results suggest that impaired physical fitness is not a barrier to continuing military service for USAF members with HIV infection. Interestingly, we observed improved performance in several test components after HIV diagnosis, which suggests that members may have increased their physical conditioning as part of improved health-seeking behaviors.

Despite advances in medical therapy, physical and functional limitations are commonly observed in HIV-infected populations. For example, HIV infection can be complicated by skeletal muscle wasting, particularly metabolically active lean tissue, which has been associated with increased all-cause mortality and accelerated disease progression.[24–26] In a study of over 900 patients with skeletal muscle and adipose tissue assessments by magnetic resonance imaging, lower muscle mass was independently associated with an increased risk of mortality.[12] USAF fitness tests assessed muscle strength by timed push-ups and sit-ups. Although muscle strength was statistically lower post-HIV compared with controls, both push-up and sit-up counts were also statistically lower pre-HIV compared with controls. The availability of preinfection fitness test data was essential because analyses demonstrated that these characteristics were present before HIV infection and thus eliminated HIV as the explanation for lower muscle strength compared with controls. In addition, cases improved muscle strength after HIV infection as demonstrated by statistically higher push-up and sit-up counts compared with pre-HIV values. These results suggest that HIV-associated reduction in muscle strength is either not present in a population or can be mitigated by improved physical conditioning.

HIV infection is also associated with decreased exercise and activity tolerance. For example, 1 study observed a decrease in peak aerobic capacity with 6-minute walk test results below the age-specific threshold in 24% of HIV-infected individuals.[27] While not as commonly noted in activities of daily living, limitations are particularly evident in vigorous activities ranging from 8% of asymptomatic individuals to 58% of persons with AIDS.[19,28] Even in those on ART, limitations in oxygen delivery to muscles during exercise have been noted with an approximate decrease of 70% of maximum predicted maximal oxygen uptake and significantly lower lactic acid thresholds.[29] Although functional data, such as oxygen delivery and uptake, were not specifically measured in our study, performance on the 1.5-mile run component of the fitness test can serve as a surrogate for these assessments. USAF members performed the 1.5-mile run in approximately 12 minutes, and these values did not differ pre-HIV or post-HIV, or when compared with controls. It is possible that functional limitations may be minor or unapparent in HIV-infected persons who perform regular vigorous exercise and maintain a high level of physical conditioning before HIV infection.

There are several possible explanations as to why HIV infection did not seem to substantially impact exercise performance in our study in contrast to other studies. For example, most published studies are not directly comparable since mild to

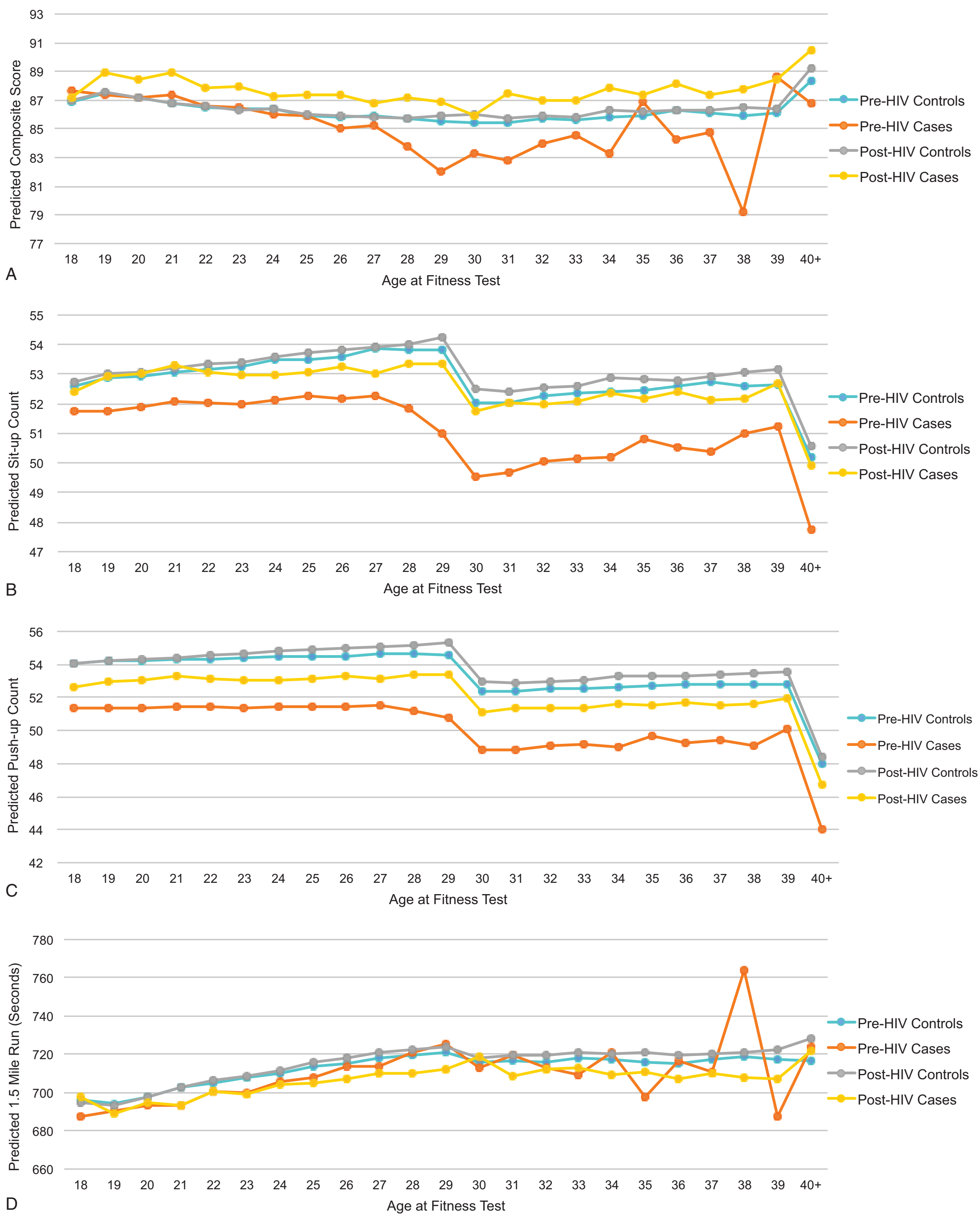

Figure 2. Adjusted fitness test performance by age and HIV status.

moderate physical activity endpoints, such as 6-minute walk, chair rise time, and gait speed, were evaluated.[18,19] Studies involving vigorous activities are limited, and usually involved structured exercise programs in persons without a high level of physical conditioning before study entry.[14,20,22] This is in contrast to the USAF population who were required to continually maintain fitness standards. Patient characteristics such as advanced HIV disease with AIDS and/or low CD4 counts have been associated with impairments in both muscle strength and aerobic function.[7,14,30] However, USAF members are typically diagnosed early due to mandated HIV testing with relatively preserved CD4 counts, and we did not observe differences in exercise performance for those with CD4 counts below 350 cells/μL. Lower composite and "excellent" scores were observed for persons with nonsuppressed VLs (≥50 copies/mL). This most likely represents the subgroup which had not

Table 2

Cross-sectional regression models predicting body composition and performance for last fitness test pre-HIV and first fitness test post-HIV for cases compared with controls.

Regression model	HIV-positive	Age at test 30–39	Age at test 40+	Rank, Officer	Normal weight	Overweight	Obese	Constant	F/X^2	R^2
Pre-HIV† cases vs pre-HIV controls										
Body mass index	−0.79**	2.14***	2.40***	0.15	–	–	–	24.48***	35.4***	0.078
Abdominal circumference	0.17	1.23***	2.18***	0.38	1.50	4.35***	7.24***	29.20***	169.5***	0.419
Composite score	−1.14	−3.12***	−0.84	2.47***	−1.05	−7.49***	−15.24***	90.90***	69.7***	0.259
Excellent vs not excellent‡	−0.21	−1.04***	−0.32	0.53**	0.55	−0.77	−2.40*	−0.41***	274.5***	0.119
Sit-up count	−1.18	−5.78***	−8.80***	1.03	−2.09	−3.96	−6.05*	56.20***	30.3***	0.099
Push-up count	−2.78**	−4.91***	−10.49***	2.60***	−2.47	−2.67	−4.36	56.20***	14.3***	0.048
1.5-mile run, s	−1.87	17.08	−52.55	−17.58	3.43	39.50	113.6**	663.0***	6.6***	0.043
Post-HIV§ cases vs post-HIV controls										
Body mass index	−0.49*	2.19***	2.26***	0.03	–	–	–	24.47***	34.6***	0.074
Abdominal circumference	−0.48**	1.44***	2.22***	0.34	2.69***	5.40***	8.14***	28.04***	176.5***	0.419
Composite score	0.63	−3.31***	−0.91	2.51***	0.37	−5.79***	−12.51***	89.43***	64.3***	0.239
Excellent vs not excellent‡	0.28	−1.06***	−0.51	0.54***	0.71	−0.60	−1.68*	−0.55	271.5***	0.116
Sit-up count	0.22	−5.86***	−8.07***	0.88	1.02	−0.72	−1.90	53.09***	28.2***	0.095
Push-up count	−1.63*	−4.93***	−9.83***	2.66***	1.97	1.81	0.74	51.71***	13.6***	0.046
1.5-mile run, s	14.37	10.02	−21.61	−18.71	−7.29	27.77	99.22*	673.4***	7.0***	0.039

HIV = human immunodeficiency virus.
† Most recent fitness test before last negative HIV test date.
‡ Logistic regression.
§ First fitness test after HIV diagnosis.
* $P<0.05$.
** $P<0.01$.
*** $P<0.001$.

initiated ART since VL suppression is high (>90%) for those on ART in our population.[31] This presumed lack of ART use may be a marker for reduced interest in personal health or health-seeking behaviors in this subgroup compared with our overall population, which may account for these findings. Other studies evaluating the impact of effective ART on fitness performance have been variable, with several studies showing no impact on aerobic performance or cardiac function.[32,33] In addition, we did not observe any differences in fitness outcomes when comparing fitness tests directly before and after HIV infection, when members were either ART-naïve or recently started on ART, which suggests that other nonmeasured factors may be involved.

Since exercise performance can diminish with age, the younger age of our USAF population is an important feature of our study compared with the predominance of older individuals in other studies. For example, 1 study showed greater loss of physical function in those with HIV infection compared with uninfected persons; however, the median age was 50 years.[34] This is in contrast to our USAF population who had a mean age of 28 years at HIV diagnosis. Interestingly, the younger age group (age ≤44 years) of HIV-infected individuals in this study reported higher physical function than those without HIV infection, and this was the only age group to report similar frequency of exercise compared with HIV-uninfected persons. This raises the question of whether physical inactivity may play a larger role in study outcomes than physical limitations attributed to HIV infection. Physical inactivity may be a significant confounder as 1 study observed that fewer HIV-infected persons met US Department of Health and Human Services Healthy People 2010 physical activity recommendations than persons in the general population.[35] Since our USAF population is required to maintain fitness, it is possible that HIV infection minimally impacts physical function in persons with higher levels of physical conditioning at the time of HIV acquisition.

This study is the first to evaluate longitudinal physical fitness assessments in HIV-infected persons. Study strengths include the availability of preinfection data and the evaluation of multicomponent standardized fitness tests that assessed both muscle strength and aerobic function in both cases and controls spanning an entire decade. Limitations include the retrospective study design and inability to assess additional aspects of ART use including potential differences in fitness by use of specific treatment regimens and timing of ART initiation. Data for comorbid conditions were also unavailable. Behaviors that may have impacted physical performance, such as routine exercise habits, smoking, and diet, were not captured as part of the standardized fitness assessment.

The benefits of physical activity in the HIV-infected population have been well-documented. Progressive resistive exercise in HIV-infected individuals resulted in improvement in weight, body composition, and lean muscle mass, and a 6-month aerobic and resistance exercise program resulted in decreased heart rate in participants.[10,22,36] Exercise has also been associated with improved cognition with reduced impairments of working memory and speed of information processing.[22,37] Participation in a regular exercise program has also been shown to improve self-efficacy, mood, and fatigue resulting in higher life-satisfaction scores in HIV-infected individuals.[22,38–40] The results of our study show that a high level of exercise performance can be both preserved and improved in individuals with HIV, allowing them to gain the benefits of continued physical exercise despite potential limitations of the disease process. Providers should continue to encourage participation in regular physical activity due to the physical, mental, and emotional benefits of exercise observed in HIV-infected patients.

Table 3

Random-effects regression models predicting body composition and fitness performance with robust standard errors.

	HIV-positive	Number of tests	Age at test 30–39	Age at test 40+	Rank, Officer	Normal weight	Overweight	Obese	Constant	Wald X^2
Pre-HIV vs post-HIV cases										
Body mass index	−0.10	0.13***	0.10	0.44	−0.69				24.22***	68.0***
Abdominal circumference	−0.33*	0.01	0.27	1.05***	0.39	1.42***	3.41***	4.75***	29.81***	313.1***
Composite score	0.08	0.34***	1.43*	3.15**	1.96	1.02	−4.13***	−6.72***	85.40***	159.6***
Excellent vs not excellent†	0.13	0.22***	0.16	0.72	1.21	0.26	−1.31	−2.24**	−1.74*	139.6***
Sit-up count	0.56	0.31***	−1.21	−3.93***	−0.86	4.36**	3.18*	2.94	46.54***	39.0***
Push-up count	0.15	0.36***	−0.35	−5.52***	−0.93	2.09	1.41	0.66	47.97***	34.3***
1.5-mile run, s	8.37	0.05	−11.95	21.87	−16.12	−21.57*	12.04	46.54**	706.7***	44.8***
Pre-HIV cases vs pre-HIV controls										
Body mass index	−1.01***	0.18***	−0.08	−0.54***	0.04				25.06***	563.1***
Abdominal circumference	−0.25	−0.01	0.49***	0.84***	0.66***	1.43***	3.26***	5.06***	30.04***	2352***
Composite score	−0.76	0.47***	−0.11	1.87***	2.34***	2.60	−2.21	−7.93***	84.42***	1153***
Excellent vs not excellent†	−0.38	0.24***	−0.07	0.72***	0.92***	1.04*	−0.70	−2.40***	−2.14***	927.2***
Sit-up count	−1.28	0.41***	−1.63v**	−3.66***	−0.33	2.84**	1.73	0.46	49.51***	385.6***
Push-up count	−3.01***	0.22***	−2.13***	−6.81***	0.65	0.25	−0.47	−1.77	53.69***	227.3***
1.5-mile run, s	0.69	0.65	−3.21	2.17	−24.22***	−26.84**	3.56	33.65**	717.7***	342.2***
Post-HIV cases vs post-HIV controls										
Body mass index	−0.76**	0.17***	−0.06	−0.52***	−0.17				25.15***	773.8***
Abdominal circumference	−0.55***	−0.01	0.41***	0.64***	0.60***	1.43***	3.24***	4.99***	30.08***	2809***
Composite score	0.81	0.41***	0.16	2.44***	2.53***	2.05*	−2.39**	−8.24***	84.90***	1145***
Excellent vs not excellent†	0.56*	0.23***	0.05	0.99***	0.97***	1.05**	−0.59	−2.25***	−2.20***	1235***
Sit-up count	−0.28	0.38***	−1.56***	−3.67***	−0.50	2.97***	1.90*	0.65	49.55***	470.2***
Push-up count	−1.42*	0.29***	−2.24***	−7.21***	0.55	0.73	0.16	−1.15	53.04***	331.3***
1.5-mile run, s	−1.10	1.08**	−3.93	10.58	−28.44***	−20.22**	9.23	47.53***	710.7***	370.3***
Post-HIV cases: CD4 count at fitness test ≥350 vs <350 cells/μL	**CD4 ≥350**	**Number of tests**	**Age at test 30–39**	**Age at test 40+**	**Rank, Officer**	**Normal weight**	**Overweight**	**Obese**	**Constant**	**Wald X^2**
Body mass index	−0.32	0.23***	0.07	0.36	−0.91				24.72***	43.92***
Abdominal circumference	0.51	0.02	0.20	0 .62	0 .36	−0.79	1.24	3.06**	31.29***	89.11***
Composite score	1.21	0.37	2.53	6.67***	2.79	3.43	−0.73	−3.91	81.49***	82.41***
Excellent vs not excellent†	0.74	0 .19	1.25*	3.39***	1.13	−0.81	−2.06*	−4.45***	−1.16	27.96***
Sit-up count	−0.99	0.24	−1.22	−3.29*	−0.69	0.12	0.06	0.79	52.49	7.91
Push-up count	1.04	0.42	−0.01	−4.51*	−0.86	−3.51	−1.18	−1.74	52.97***	24.87**
1.5-mile run, s	0.35	−5.80**	−28.53	25.08	−31.77	−17.35	6.63	55.56*	740.27***	40.93***
Post-HIV cases: viral load at fitness test ≥50 vs <50 copies/mL	**VL ≥50**	**Number of tests**	**Age at test 30–39**	**Age at test 40+**	**Rank, Officer**	**Normal weight**	**Overweight**	**Obese**	**Constant**	**Wald X^2**
Body mass index	0.32	0.27***	0.09	0.44	−0.99				24.22***	43.23***
Abdominal circumference	0.19	0.06	0.23	0.68	0.37	−0.74	1.25	3.01**	31.54***	88.81***
Composite score	−2.71***	0.04	2.43	6.33***	3.19*	2.99	−0.84	−3.64	84.72***	94.19***
Excellent vs not excellent†	−1.14**	0.06	1.20*	3.20***	1.28	−1.09	−2.18*	−4.41***	0.51	33.56***
Sit-up count	−1.24	0.07	−1.35	−3.57*	−0.59	−0.13	−0.03	0.93	52.74***	9.30
Push-up count	−0.72	0.34	−0.02	−4.57*	−0.69	−3.55	−1.17	−1.67	54.38***	22.92**
1.5-mile run, s	1.11	−5.69***	−28.34	25.53	−31.94	−17.38	6.43	55.25*	739.84***	40.85***

HIV = human immunodeficiency virus.
† Logit models.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

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