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Comparing self-reported physical activity and sedentary time to objective fitness measures in a military cohort

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ABSTRACT

Objectives: Regular vigorous physical activity (PA) and high levels of physical fitness (PF) confer health benefits. Conversely, sedentary time is a risk factor for chronic illness, independent of PA. We evaluated associations between self-reported PA, sedentary time, and objective PF measures in military Service members.

Design: Cross-sectional study including 10,105 Air Force Millennium Cohort participants with a valid physical fitness assessment (PFA).

Methods: Linear regression assessed associations between self-report PA, screen time, and usual activity and abdominal circumference (AC) and VO_2 max; logistic regression was used for PFA failure. We stratified by age and sex.

Results: Men who self-reported high versus low levels of PA had greater AC (19–29 years: $\beta = 0.23$ in., 95% CI 0.07, 0.39; 30–39 years: $\beta = 0.45$ in., 95% CI 0.17, 0.72). High versus low self-reported PA was also associated with greater VO_2Max ($\beta =$: 0.81–1.41 mL/kg/min). Self-reported strength training for ≥2 days/week was associated with greater VO_2Max in 19–29 year old men ($\beta = 0.84$ mL/kg/min, 95% CI 0.09, 0.60) and 30–39 year old women ($\beta = 0.74$ mL/kg/min, 95% CI 0.02, 1.46). For younger men and women,<2 h of screen time/day was associated with greater VO_2Max (Males 19–29 years: $\beta = 0.23$ mL/kg/min, 95% CI 0.44, 1.26; Females 19–29 years: $\beta = 0.83$ mL/kg/min, 95% CI 0.25, 1.42). PA was not associated with PFA failure, while screen time was (Males OR: 0.32–0.65, 95% CI 0.17–0.92, $p < 0.001$–0.016).

Conclusions: Self-reported PA and screen time were associated with some objective PF measures, including VO_2Max and AC. However, screen time alone was associated with PFA failure.

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1. Introduction

Regular vigorous physical activity (PA) contributes long-term health benefits, such as reduced risk of hypertension, coronary artery disease, and Type 2 diabetes.[1–3] Similarly, high levels of physical fitness have been linked to better overall health and reduced risk of sudden cardiac death.[4,5] A growing body of evidence indicates that sedentary time is a risk factor for chronic illness, independent of PA.[6,7] Department of Defense (DoD) regulations require that "Service members (SM) shall maintain physical readiness through appropriate nutrition, health, and fitness habits.[8]" While some Service members may be at duty stations that afford opportunities for unit or individual physical training during working hours, the DoD does not regulate, require, or systematically assess SMs' physical activity. However, physical fitness components (such as cardiorespiratory endurance, body composition) are assessed on an annual or semi-annual basis in the military using standardized physical fitness assessments (PFAs). Recent studies found 57%–75% of military populations met the Healthy People 2010 guidelines for moderate or vigorous PA, but 60% of active duty SMs were nonetheless overweight or obese.[9,10]

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The degree to which U.S. SMs' usual physical activity habits correspond to objectively measured physical fitness from required PFAs has not been empirically evaluated.[11] Our study was undertaken to address this gap using self-reported physical activity measures from active duty Airmen enrolled in the Millennium Cohort Study and their corresponding objective PFA measures. We hypothesized that those with greater self-reported physical activity would have lower abdominal circumference (AC), greater cardiorespiratory fitness, and higher odds of passing the Air Force Physical Fitness Assessment. Understanding relationships between self-reported PA and physical fitness assessments could lead to the development of evidence-based strategies to support and encourage physical activity for SMs, ultimately resulting in higher levels of physical combat readiness and lower risk of injuries and chronic illness.

2. Methods

We conducted a cross-sectional study using Air Force participants enrolled in the Millennium Cohort Study (MCS) to investigate any association between self-reported physical activity and sedentary behaviors, and objective physical fitness measures from Air Force PFAs. The MCS was created in response to an Institute of Medicine (IOM) report, *Measuring Health*, which recommended systematic collection of longitudinal, population-based data on the health of Service members to study health effects of military service and deployment.[12] Launched in July 2001, MCS has baseline and triennial follow-up surveys that include health-related behavior questions.

A total of 22,663 active duty Air Force members completed a MCS survey between May 2007 and December 2008. Of these, 13,646 also completed a PFA within the study time frame. Individuals missing data for the aerobic or AC component of the PFA (n = 1105) or not completing the 1.5 mile run were excluded (n = 317). Finally, those over the age of 39 (small sample size) or missing data for any variable of interest, were excluded, leaving a final study sample of 10,105. This study was approved by the Naval Health Research Center and the Uniformed Services University Institutional Review Boards and conducted in compliance with all applicable Federal regulations governing the protection of human subjects (protocol NHRC.2000.0007).

PFA data were obtained from the Information Delivery Division, Health Information Technology Directorate, Defense Health Agency. The objective fitness outcomes included AC, cardiorespiratory fitness (estimated VO_2Max calculated from the PFA 1.5-mile run time), and PFA pass/fail results.

AC was measured for each Air Force SM at the time of the PFA and recorded in 0.5 in. intervals.[13] Values $\leq$22 in. or $\geq$50 in. were considered implausible and coded as missing (n = 2).

Time to complete the 1.5 mile run was used to estimate VO_2Max (mL/kg/min) based on the following gender-specific formulas:[13]

$$\underline{\text{Men}}: \text{Estimated } VO_2\text{Max} = 88.02 + 3.716 - (0.1656 \times \text{weight in pounds}/2.2 \text{ pounds per kilogram}) - (2.767 \times \text{run time})$$

$$\underline{\text{Women}}: \text{Estimated } VO_2\text{Max} = 88.02 - (0.1656 \times \text{weight in pounds}/2.2 \text{ pounds per kilogram}) - (2.767 \times \text{run time}).$$

The Air Force then assigned age and sex-weighted scores to the results of each SM's required PFA components (AC, 1.5-mile run, 2-min pushups, and 2-min crunches), and these individual component scores were summed, resulting in a scaled composite score of 0–100. This composite score was then used to determine whether a SM passed the PFA, with a passing score >75 (10).

Demographic characteristics were obtained from the Defense Manpower Data Center (DMDC), or secondarily from MCS surveys. Additionally, self-reported data on smoking behavior, height and weight, PA and sedentary behavior were obtained from MCS survey responses.

Questions regarding weekly levels of moderate and vigorous PA were modified versions of questions included in the 2001 National Health Interview Survey (NHIS) used by the Centers for Disease Control and Prevention:

"In a typical week, how much time do you spend participating in:

1. Vigorous exercise or work that causes heavy sweating or large increases in breathing or heart rate? (such as running, active sports, marching, biking)
2. Moderate or light exercise or work that causes light sweating or slight increases in breathing or heart rate? (such as walking, cleaning, slow jogging)"

Participants self-reported days per week and minutes per day for each type of activity; there were additional options for "None" and/or "Cannot physically do", which were recorded as 0 min per week. From these responses, total minutes per week of each type of exercise were summed and categorized to represent "low," "medium," and "high" weekly PA levels in a manner similar to the *2008 Physical Activity Guidelines for Americans*.[14] High PA was defined as at least 300 min of moderate activity, 150 min of vigorous activity, or an equivalent combination of both in a given week. Medium weekly PA was defined as at least 150 min of moderate activity, 75 min of vigorous activity, or an equivalent combination of both, but not meeting criteria for High PA. Low PA was any self-reported weekly activity not meeting the medium threshold, including no activity, or self-reporting inability to physically perform these activities.[14] Values greater than 6720 min per week (roughly 16 h per day, 7 days per week), or more than 960 min (16 h) on any given day were considered implausible and categorized as missing (n = 9).

Time spent strength training was determined from the question "In a typical week, how much time do you spend participating in strength training or work that strengthens your muscles (such as lifting/pushing/pulling/weights)?" Similar to the moderate and vigorous activity questions, participants self-reported days per week and minutes per day, with options for "None" and "Cannot physically do." For these analyses, only days per week were used. Responses were dichotomized to performing strength training less than twice per week and at least twice per week per the 2008 Physical Activity Guidelines for Americans recommendations.[14] Any self-reported values greater than 6720 min per week or 960 min on any given day, were considered implausible and coded as missing (n = 1).

In addition to self-reported weekly PA, participants were also asked to describe their usual daily activity level. This question was derived from the 2000 National Health and Nutrition Examination Survey (physical activity question 180). Four response options were available: "1. You sit during the day and do not walk much; 2. You stand or walk a lot during the day, but do not carry or lift things often; 3. You lift or carry light or heavy loads, or climb stairs or hills often; and 4. You do heavy work or carry heavy loads often." For these analyses, the latter two categories were combined into a "high" usual daily activity level, while the former two were labeled "low" and "medium" usual daily activity, respectively.

Screen time was assessed based on hours spent sitting and watching TV or videos or using a computer in a typical day (<2 h, 2 to <4 h, 4 to <8 h, and >8 h).

Table 1
Sex- and age-stratified Air Force physical fitness assessment (PFA) results and self-reported physical activity, behavioral, and demographic characteristics.

	Males				Females			
	19–29 years old (n = 5,013)		30–39 years old (n = 1,855)		19–29 years old (n = 2,653)		30–39 years old (n = 584)	
	mean	(SD)	mean	(SD)	mean	(SD)	mean	(SD)
Abdominal circumference (in.)	33.3	2.8	34.8	2.8	29.7	2.6	30.5	2.6
1.5 mile run (seconds)	719.3	90.0	730.2	88.4	849.9	102.8	853.7	100.7
VO_2Max (mL/kg/min)	44.9	5.0	43.8	5.1	38.2	5.3	37.5	5.3
Push-ups (count)	54.9	9.6	49.5	7.8	34.7	10.0	30.9	10.2
Crunches (count)	51.9	7.8	48.0	7.5	44.9	9.2	40.6	7.6
	n	%	n	%	n	%	n	%
Physical fitness assessment (PFA) results								
Pass	4829	96.3	1779	95.9	2551	96.2	561	96.1
Fail	184	3.7	76	4.1	102	3.8	23	3.9
Physical activity[a]								
Low	939	18.7	402	21.7	428	16.1	100	17.1
Medium	1608	32.1	729	39.3	941	35.5	225	38.5
High	2466	49.2	724	39.0	1284	48.4	259	44.4
Strength training (days per week)								
0–1	1276	25.5	630	34.0	902	34.0	231	39.6
2+	3737	74.6	1225	66.0	1751	66.0	353	60.5
Daily screen time (hours watching TV/videos or at a computer)								
<2	615	12.3	125	6.7	303	11.4	47	8.1
2–3	1,959	39.1	500	27.0	851	32.1	140	24.0
4–7	1467	29.3	687	37.0	701	26.4	176	30.1
8+	972	19.4	543	29.3	798	30.1	221	37.8
Usual daily activity[b]								
Low	1261	25.2	750	40.4	975	36.8	280	48.0
Medium	1857	37.0	772	41.6	1099	41.4	237	40.6
High	1895	37.8	333	18.0	579	21.8	67	11.5
Body mass index[c]								
Underweight	26	0.5	12	0.7	69	2.6	7	1.2
Normal	2176	43.4	488	26.3	1,770	66.7	349	59.8
Overweight	2383	47.5	1063	57.3	726	27.4	191	32.7
Obese	428	8.5	292	15.7	88	3.3	37	6.3
Smoking status[d]								
Non-smoker	3170	63.2	1473	79.4	1753	66.1	464	79.5
Smoker	1843	36.8	382	20.6	900	33.9	120	20.6
Race/Ethnicity								
White	3987	79.5	1511	81.5	1,827	68.9	418	71.6
Black	465	9.3	150	8.1	468	17.6	97	16.6
Other	561	11.2	194	10.5	358	13.5	69	11.8
Marital Status[e]								
Married	2357	47.0	1572	84.7	1.143	43.1	365	62.5
Not married	2656	53.0	283	15.3	1510	56.9	219	37.5
Education								
Less than a college degree	4164	83.1	1049	56.6	2232	84.1	303	51.9
College degree or more	849	16.9	806	43.5	421	15.9	281	48.1

[a] Physical activity definitions (based on *2008 Physical Activity Guidelines for Americans*): Low is less than 150 min of light/moderate PA, less than 75 min of vigorous PA or equivalent combination of both. Medium is 150–300 min of light/moderate PA, 75 to 150 min of vigorous PA or an equivalent combination of both, High is more than 300 min of minutes of light/moderate PA, more than 150 min of vigorous PA or equivalent combination of both.
[b] Daily activity definitions: Low is sitting during the day and not walking much. Medium is standing or walking a lot during the day, but not carrying or lifting things often. High is lifting or carrying loads (light or heavy) often, climbing stairs or hills often, or doing heavy work.
[c] BMI: Underweight <18.5, Normal 18.5–24.9, Overweight 25–29.9, Obese ≥30.
[d] Smoking status defined by self-reported use any of cigarettes in the past year.
[e] Not married includes never married, previously married, widowed, separated, and divorced.

As sex and age both influence PF and PA, all analyses were conducted separately for men and women and by age category (19–29 and 30–39 years). Frequency of categorical variables and means for continuous variables were examined. Relationships between AC and estimated VO_2Max and independent variables were modeled using linear regression. Multivariable logistic regression was used to assess relationships between independent variables and PFA failure. The four independent variables of interest, (1) PA (low, medium, high), (2) strength training (0–1, 2+ days/wk), (3) screen time (<2, 2–3, 4–7, 8+), and usual daily activity (low, medium, high), were included in all regression model, adjusting for body mass index (BMI), smoking status, race/ethnicity, marital status, and education. Additionally, AC models controlled for age and sex strata-specific quartiles of the other PFA components (run time, push-ups, and crunches), while VO_2Max models controlled for age and sex strata-specific quartiles of the remaining PFA components (AC, push-ups, and crunches). Due to the small number of PFA failures, the PFA pass/fail model was stratified by sex only while controlling for age.

3. Results

Self-reported high PA levels were most frequently reported by younger men and women (19–29 years old, 49.2% and 48.4%, respectively), while self-reported strength training ≥2 times per week was most often reported by younger men (74.6%, Table 1). Younger men also more frequently reported high usual daily activity (37.8%). Notably, only 19% of younger men reported very high

Table 2
Age- and sex-stratified multivariate linear regression models examining the association between self-reported physical activity variables and abdominal circumference*.

	Males						Females					
	19–29 years old (n = 4,970)			30–39 years old (n = 1,838)			19–29 years old (n = 2,609)			30–39 years old (n = 562)		
	β	95%CI	p-value	β	95%CI	p-value	β	95%CI	p-value	β	95%CI	p-value
Intercept	30.65	30.37, 30.92		31.35	30.91, 31.79		27.82	27.45, 28.18		28.56	27.79, 29.33	
Physical activity[a]												
Low	Ref			Ref			Ref			Ref		
Medium	0.12	−0.05, 0.28	0.17	0.27	0.00, 0.53	0.050	0.24	−0.01, 0.49	0.061	0.14	−0.38, 0.65	0.60
High	0.23	0.07, 0.39	0.005	0.45	0.17, 0.72	0.001	0.21	−0.03, 0.45	0.093	0.47	−0.04, 0.98	0.070
Strength training (days per week)												
0–1	Ref			Ref			Ref			Ref		
2+	0.08	−0.06, 0.21	0.27	−0.13	−0.35, 0.08	0.22	0.18	0.00, 0.36	0.047	0.05	−0.32, 0.42	0.78
Daily screen time (hours watching TV/videos or at a computer)												
<2	0.03	−0.19, 0.25	0.78	0.15	−0.28, 0.57	0.50	0.24	−0.05, 0.53	0.10	0.17	−0.50, 0.85	0.62
2–3	0.14	−0.03, 0.32	0.11	−0.03	−0.31, 0.25	0.81	0.06	−0.16, 0.28	0.60	−0.18	−0.65, 0.29	0.45
4–7	0.08	−0.10, 0.25	0.39	−0.01	−0.26, 0.25	0.96	0.04	−0.18, 0.26	0.72	−0.03	−0.47, 0.41	0.91
8+	Ref			Ref			Ref			Ref		
Usual daily activity[b]												
Low	Ref			Ref			Ref			Ref		
Medium	−0.32	−0.47, −0.16	<0.001	−0.24	−0.47, −0.01	0.040	−0.14	−0.33, 0.06	0.16	−0.44	−0.83, −0.05	0.027
High	−0.42	−0.59, −0.26	<0.001	−0.31	−0.61, −0.01	0.044	0.075	−0.16, 0.31	0.54	−0.39	−0.97, 0.18	0.18
BMI[c]												
Underweight	−2.06	−2.83, −1.28	<0.001	−0.34	−1.54, 0.87	0.58	−2.27	−2.78, −1.76	<0.001	−0.71	−2.27, 0.84	0.37
Normal	Ref			Ref			Ref			Ref		
Overweight	2.85	2.73, 2.97	<0.001	2.70	2.46, 2.93	<0.001	2.74	2.55, 2.93	<0.001	2.53	2.14, 2.91	<0.001
Obese	5.64	5.42, 5.85	<0.001	5.09	4.76, 5.42	<0.001	4.74	4.28, 5.21	<0.001	5.07	4.33, 5.81	<0.001

* Model controlled for race/ethnicity, marital status, education, and smoking status, as well as quartiles of run time, push-ups, and crunches.
[a] Physical activity definitions: Low is less than 150 min of light/moderate PA, less than 75 min of vigorous PA or equivalent combination of both. Medium is 150–300 min of light/moderate PA, 75 to 150 min of vigorous PA or an equivalent combination of both, High is more than 300 min of minutes of light/moderate PA, more than 150 min of vigorous PA or equivalent combination of both.
[b] Daily activity definitions: Low is sitting during the day and not walking much. Medium is standing or walking a lot during the day, but not carrying or lifting things often. High is lifting or carrying loads (light or heavy) often, climbing stairs or hills often, or doing heavy work.
[c] BMI: Underweight <18.5, Normal 18.5–24.9, Overweight 25–29.9, Obese ≥30.

screen time (8+ hours per day watching TV/videos or at a computer), while approximately 29–38% of all other age and sex categories reported this amount of screen time. A majority of men (but not women) in our study population, regardless of age, were categorized as overweight or obese according to their BMI (younger men: 56.1%, older men: 73.0%; younger women: 30.7%, older women: 39.0%).

Associations between AC and self-reported PA differed by age and sex strata (Table 2). Men with high levels of PA had AC measurements greater than men with low levels of PA (younger: $\beta = 0.23$ in., 95% CI 0.07, 0.39; older: $\beta = 0.45$ in., 95% CI 0.17, 0.72). Among women, AC was not significantly associated with PA (younger: $\beta = 0.21$ in., 95% CI −0.03, 0.45; older: $\beta = 0.47$ in., 95% CI −0.04, 0.98). Strength training was associated with a greater AC in younger women (≥2×/week vs. 0–1: 0.18 in., 95% CI 0.00, 0.36), but not older women. Both medium and high categories of usual daily activity were associated with lower AC in men (β: −0.42 to −0.24 in.). Hours of screen time was not associated with AC for any age and sex stratum.

Associations between self-reported activity and estimated VO_2Max also differed by age and sex strata (Table 3). High self-reported PA was associated with significantly greater VO_2Max in all age and sex strata (β: 0.81 to 1.41 mL/kg/min) compared to low self-reported PA, while an association between medium PA and greater VO_2Max was observed in men only (younger men: $\beta = 0.38$ mL/kg/min, 95% CI 0.07, 0.69; older men: $\beta = 0.50$ mL/kg/min, 95% CI 0.03, 0.97). Strength training for ≥2 days per week compared to <2 days per week was associated with greater VO_2Max in younger men and older women. For both younger men and women, compared to 8 or more hours of screen time, <2 h of screen time per day was associated with significantly greater VO_2Max (0.84 and 0.83 mL/kg/min, respectively). There was no association between self-reported usual daily activity and VO_2Max in any age and sex stratum.

Finally, we examined whether or not demographic, health, and behavioral factors were associated with failing the PFA (Supplementary Table 4). Hours of daily screen time were associated with lower odds of PFA failure for men (4–7 h: OR = 0.65, 95% CI 0.46, 0.92; 2–3 h: OR = 0.50, 0.34, 0.72; <2 h: OR = 0.32, 95% CI 0.17, 0.60). Screen time was not associated with PFA failure in women, nor were there any associations between other self-reported activity variables (PA, usual daily activity, and strength training) and PFA failure in any age and sex stratum.

4. Discussion

An overwhelming majority (81.5%) of Air Force men and women of all ages in this study reported they met or exceeded physical activity recommendations (as outlined in the 2008 Physical Activity Guidelines).[14] Associations between these measures and objective physical fitness outcomes varied by age and sex. Counterintuitively, men with medium to high self-reported PA and younger women with greater self-reported strength training had greater AC than those with less activity. However, men reporting medium to high PA and women with high PA had greater estimated VO_2Max, as did men and women reporting lower screen time. Increasing screen time was associated with greater odds of failing the PFA for men.

Contrary to our hypothesis, this study found that high levels of PA were associated with greater, not lesser, AC, particularly in men. Previous studies of waist circumference and self-reported physical activity in the US adult population found an inverse relationship between these factors.[15–17] Findings from our study may differ from trends in the general U.S. population since the military represents a relatively fit and healthy population in which individuals reporting high levels of PA may include more muscular body types than those reporting low levels of PA. It is also possible that observed differences are partially rooted in differences in data collection methods. While NHANES and NHIS surveys focus

Table 3
Age- and sex-stratified multivariate linear regression models examining the association between self-reported physical activity variables and VO_2Max*.

	Males						Females					
	19–29 years old (n = 4,970)			30–39 years old (n = 1,838)			19–29 years old (n = 2,609)			30–39 years old (n = 562)		
	β	95%CI	p-value	β	95%CI	p-value	β	95%CI	p-value	β	95%CI	p-value
Intercept	49.35	48.84, 49.86		47.91	47.16, 48.66		41.39	40.68, 42.11		39.87	38.40, 41.33	
Physical activity[a]												
Low	Ref			Ref			Ref			Ref		
Medium	0.38	0.07, 0.69	0.017	0.50	0.03, 0.97	0.036	0.08	−0.42, 0.58	0.75	0.28	−0.72, 1.28	0.59
High	0.81	0.52, 1.10	<0.001	1.30	0.82, 1.78	<0.001	1.21	0.72, 1.69	<0.001	1.41	0.42, 2.40	0.006
Strength training (days per week)												
0–1	Ref			Ref			Ref			Ref		
2+	0.34	0.09, 0.60	0.007	0.35	−0.03, 0.73	0.070	0.26	−0.10, 0.62	0.15	0.74	0.02, 1.46	0.045
Daily screen time (hours watching TV/videos or at a computer)												
<2	0.84	0.44, 1.26	<0.001	0.65	−0.10, 1.41	0.089	0.83	0.25, 1.42	0.005	1.23	−0.08, 2.55	0.067
2–3	0.14	−0.18, 0.47	0.39	0.49	0.00, 0.99	0.050	0.10	−0.34, 0.54	0.64	0.77	−0.15, 1.70	0.10
4–7	0.01	−0.31, 0.33	0.96	0.58	0.13, 1.03	0.011	−0.20	−0.65, 0.24	0.37	0.84	−0.02, 1.70	0.057
8+	Ref			Ref			Ref			Ref		
Usual daily activity[b]												
Low	Ref			Ref			Ref			Ref		
Medium	−0.09	−0.38, 0.20	0.55	−0.03	−0.43, 0.38	0.89	0.22	−0.17, 0.61	0.26	0.15	−0.62, 0.92	0.71
High	−0.10	−0.41, 0.21	0.53	−0.26	−0.79, 0.28	0.34	−0.06	−0.54, 0.41	0.79	0.13	−1.00, 1.26	0.82
BMI[c]												
Underweight	1.07	−0.38, 2.51	0.15	−0.33	−2.46, 1.80	0.76	0.64	−0.40, 1.68	0.23	0.86	−2.19, 3.92	0.58
Normal	Ref			Ref			Ref			Ref		
Overweight	−1.71	−1.98, −1.43	<0.001	−2.02	−2.50, −1.54	<0.001	−3.11	−3.54, −2.67	<0.001	−2.11	−2.99, −1.24	<0.001
Obese	−4.85	−5.33, −4.38	<0.001	−5.48	−6.17, −4.80	<0.001	−5.79	−6.77, −4.81	<0.001	−5.95	−7.59, −4.32	<0.001

* Model controlled for race/ethnicity, marital status, education, and smoking status, as well as quartiles of abdominal circumference, push-ups, and crunches.
[a] Physical activity definitions: Low is less than 150 min of light/moderate PA, less than 75 min of vigorous PA or equivalent combination of both. Medium is 150–300 min of light/moderate PA, 75 to 150 min of vigorous PA or an equivalent combination of both, High is more than 300 min of minutes of light/moderate PA, more than 150 min of vigorous PA or equivalent combination of both.
[b] Usual daily activity definitions: Low is sitting during the day and not walking much. Medium is standing or walking a lot during the day, but not carrying or lifting things often. High is lifting or carrying loads (light or heavy) often, climbing stairs or hills often, or doing heavy work.
[c] BMI: Underweight <18.5, Normal 18.5–24.9, Overweight 25–29.9, Obese ≥30.

on leisure time activity, the MCS's survey questions inquired about exercise and work-related moderate and vigorous PA. Therefore, many respondents likely reported a combined estimate of occupational and leisure-time activity. At least one previous study found that while leisure time activity was associated with lower waist circumference, occupational activity was associated with greater waist circumference.[16] Residual confounding lifestyle factors, such as irregular work hours and diet, may explain the occupational PA and waist circumference associations, but further investigation is warranted. Regardless, strategies for promoting overall health, including diet, should be promoted.

Interestingly, screen time was not independently associated with AC. Also, usual daily activity was significantly associated with AC in men only. Studies of sedentary behavior and AC in the US adult population also have had mixed findings. While one study found that for every 100-min increase in time spent sitting, waist circumference was 0.6 in. greater,[18] another using NHANES data showed that there was no difference in odds of having a high waist circumference between those who sat most of the day and those who had any daily activity beyond sitting, despite using the same survey question and controlling for the same variables as our study.[19] However, the thresholds used to define high waist circumference in the latter study (42.2 in. for men, 34.6 in. for women) were much higher than the average waist circumference measures for our population (more than two standard deviations in most cases). It is possible that for individuals with very high waist circumferences, the effects of sedentary behavior are different than for those with more normal waist circumferences. Further investigation of these associations is warranted to better understand these conflicting results.

In our cohort, high self-reported physical activity was associated with greater VO_2Max in all age and sex groups, while less screen time was associated with greater VO_2Max for younger men and women. These patterns are generally similar to those found in previous studies of adult populations.[20–22] However, it is important to note that while these associations were statistically significant, none of the self-reported physical activity or sedentary behavior measures were associated with a difference in VO_2Max greater than 1.5 ml/kg/min, leaving the clinical significance of these findings questionable. Increased strength training was associated with greater VO_2Max in younger men and older women and showed a trend towards significance in other age groups. It is possible that those who engage in strength training have higher levels of physical activity in general, but this was not specifically examined. Finally, self-reported PA was not associated with higher or lower odds of failing the PFA, suggesting other factors, such as motivation, may affect PFA outcomes. However, increasing PA and decreasing sedentary time remain important for overall health and wellness, and strategies to increase PA and decrease sedentary behavior in Service members should be promoted.

Potential for misclassification for self-reported PA is a limitation of this study since we relied on survey data for four PA metrics. PA has been found to be over-reported in other studies which rely on self-reported data,[23] and these measures also have weak associations with objective PA assessments, such as step counts.[12,23] Assuming this misclassification is non-differential (meaning, those with high AC or low VO_2Max are not more likely than others to overestimate their PA levels), this would bias our findings towards the null. Additionally, only those who completed an Air Force fitness test during the study period were included in our study; those who were excused from the test due to medical issues, deployment, or pregnancy, and those who had separated from the military within the study time frame were excluded. These excluded individuals may have had lower overall physical fitness than the study population, reducing the external validity of our findings. Finally, the number of younger women in our sample was small compared to the number of older women, which could have reduced statistical power for some of these comparisons.

5. Conclusions

Our study showed that Airmen who meet guidelines for PA based on 2008 Physical Activity Guidelines for Americans[3] have slightly greater abdominal circumference but greater fitness level based on VO_2Max. Findings from this study indicate self-reported PA levels may serve as an indicator of some objective measures of physical fitness for Airmen, including VO_2Max, but did not predict the odds of failing the PFA. Furthermore, our study indicates that at least in men, independent of PA, screen time is strongly associated with failing the PFA, signifying that decreasing screen time may be an important target of behavioral interventions.

Practical implications

- Physical activity and strength training do not appear to decrease abdominal circumference in a large cohort of active duty Air Force members. Holistic approaches to health which incorporate other important factors such as nutrition and sleep should be promoted.
- In Airmen, only low screen time, and not physical activity, affected the odds of failing the physical fitness test. Strategies to improve PFA pass rates should include programs to reduce sedentary time.
- To improve combat readiness and lower risks of injuries and chronic illness, strategies that motivate individuals to be physically active and that promote overall health and well-being may prove most beneficial.

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Disclaimer

The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of the Army, Department of the Air Force, Department of Veterans Affairs, Department of Defense, or the U.S. Government. Approved for public release; distribution unlimited. Human subjects participated in this study after giving their free and informed consent. This research was conducted in compliance with all applicable federal regulations governing the protection of human subjects in research (NHRC.2000.0007).

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jsams.2018.05.023.

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