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Original Research

Differences in Muscle Quantity and Quality by HIV Serostatus and Sex

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Abstract

OBJECTIVE: People with HIV (PWH) experience greater declines in both muscle function and muscle mass with aging. Whether changes in muscle quality and quantity with aging differ between men and women with HIV and the implications on muscle function are not established.
DESIGN: In coordinated substudies of the Multicenter AIDS Cohort Study and Women's Interagency HIV Study, participants completed physical function and falls assessments; total trunk/thigh density, inversely related to fatty infiltration, and area were quantified from computed tomography (CT) scans.
METHODS: Generalized linear models were used to explore variables affecting density/area, and associations between area/density and physical function and falls.
RESULTS: CT scans were available on 387 men (198 PWH) and 184 women (118 PWH). HIV serostatus was associated with greater lateralis, paraspinal, and hamstring area, but lower psoas area and density. Older age and female sex were associated with smaller trunk muscle area and lower density. Both lower muscle area and muscle density were associated with several measures of impaired physical function. The odds of falling were lower with greater hamstring density, but not associated with other measurers of muscle area or density.
CONCLUSIONS: In summary, older adults with HIV appear to have smaller and less dense (fattier) psoas, a key component in truncal stability and hip flexion that could have implications on physical function. The longitudinal associations of muscle area and density with physical function require careful investigation, with a particular focus on characteristics and interventions that can preserve muscle area, density, and function over time.

Key words: Frail, skeletal muscle, adipose tissue, sarcopenia, falls, accidental.

Background

With the widespread use of effective antiretroviral therapy (ART), people with HIV (PWH) now have a lifespan approaching that of people without HIV, and the average age of PWH in the US is now over the age of 50. The increase in average age has been accompanied by an increase in non-HIV comorbidities, in part as a consequence of effects of prior ART, chronic inflammation, immune suppression associated with HIV, and sociodemographic factors. Compared to people without HIV, PWH also appear to experience faster declines in functional measures of aging, such as gait speed and grip strength (1, 2). Although decline in physical function can be multifactorial, age-related loss of skeletal mass is a significant contributor to functional decline. Indeed, among PWH, aging is associated with greater than expected declines in lean mass (a proxy for skeletal muscle mass) (3, 4), and lower lean mass has been associated with poorer physical function in multiple cohorts (5-7).

With aging, muscle quality tends to decline before loss of muscle mass (quantity) (8-11). Thus, in addition to changes in the quantity of skeletal muscle, the quality of the muscle may provide a similar or better estimate of subsequent complications (12), including physical function impairment and falls. Muscle quality has been defined in many studies by the amount of fat deposition within muscle, as measured by the Hounsfield unit (HU) density on CT scan. Multiple large cohort studies of older adults without HIV have shown strong associations between fattier (lower density) muscle and poor physical function (13), and more hospitalizations (12), falls (14, 15), and fracture (16).

As deposition of fat in visceral and ectopic (hepatic, pericardial) locations may differ by HIV serostatus (17), the quality of muscle may also be affected by HIV and ART. We have previously shown that initiation of ART is associated with a decrease in trunk muscle density, reflecting an increase in fatty infiltration. Whether greater muscle fat in PWH has a similar effect on impaired physical function, independent of visceral adipose tissue, is not well understood. In a cross-sectional study of men with and without HIV, lower thigh muscle area and density correlated with weaker grip strength (18). Among both men and women with HIV, we found that greater trunk (psoas and paraspinal) muscle density correlated with better physical function and among men only, was associated with stronger grip strength (19). Here, we sought to (1) characterize the associations of HIV and sex on both trunk and thigh muscle density and area, and (2) to compare the relationship between muscle density and area on physical function by sex and by HIV serostatus, in an effort to understand mechanisms of impaired physical function.

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Methods

The current analysis used existing data collected from the Multicenter AIDS Cohort Study (MACS) and the Women's Interagency HIV Study (WIHS), now the MACS/WIHS Combined Cohort Study (2019-present) (20). The MACS was a prospective cohort study of men who had sex with men, who were with or at risk for HIV. The MACS was established in 1984, with enrollment at four U.S. sites: Los Angeles, CA; Pittsburgh, PA; Baltimore, MD/Washington, DC, and Chicago, IL. The WIHS was a prospective cohort study of women with and at risk for HIV established in 1994 that enrolled women over 4 recruitment waves from 10 U.S. sites: Bronx/Manhattan, NY; Brooklyn, NY; Chicago, IL; Washington, DC; San Francisco, CA; Los Angeles, CA, Atlanta, GA; Chapel Hill, NC; Miami, FL; and Birmingham, AL/Jackson, MS (21). The MACS and WIHS participants attended semiannual visits which included an interviewer-administered questionnaire, physical examination, and collection of laboratory specimens.

Between 2012 and 2015, the Bone Strength Substudy (BOSS) enrolled 399 men (ages 50-69) with HIV on ART (=199) and without HIV (n=200) from the four MACS sites. As previously published, exclusion criteria included a history of osteoporosis medication use, weight >300 pounds, and a plasma HIV-1 RNA level ≥200 copies/mL. Between 2012-2016, the Musculoskeletal Substudy (MSK) enrolled 246 women with (n=158) and without (n=88) HIV (age 40 to ≤ 65 years) from 3 WIHS sites (San Francisco, Bronx, and Chicago) (6). Exclusion criteria included weight >264 pounds, height >6 feet, pregnancy or breast-feeding within the past 6 months, type I diabetes, use of corticosteroids, use of exogenous hormones including growth hormone and hormonal contraceptives in the previous 12 months, and use of drugs used to treat osteoporosis. Both substudies were specifically designed to understand the contribution of chronic HIV and ART to bone and muscle health. The institutional review boards of participating institutions approved the study protocol. All participants provided written, informed consent.

CT Measures

Quantitative computed tomography (CT) using a single-slice CT scan at the L4-L5 region and the thigh were completed on participants at baseline. CT scans were previously read for visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT) (6) area. For this analysis, the scans were re-read at the University of Colorado to quantify total density (Hounsfield Units, HU) and area (centimeters^2) of four trunk and two thigh muscle groups. For this exploratory analysis, truncal muscle density (in Hounsfield Units, HU) and area (cm^2) from scans at baseline and week 26 were analyzed using a semi-automatic segmentation software, developed in-house using the IDL platform (Exelis Visual Information Solutions, Boulder CO). Truncal muscle groups included 1) rectus abdominis, 2) anterolateral abdominal wall muscles (external and internal oblique, and transversus abdominis), 3) psoas major, and 4) paraspinal muscles (erector spinae and transversospinalis), and thigh muscles included the hamstrings and quadriceps. The segmentation technique takes advantage of the unique CT-assessed density differences between muscle and fat and has been used in similar studies (22, 23). Muscle and fat segmentations were completed by a single analyst blinded to HIV serostatus; 5% of scans were re-analyzed by this analyst and reviewed by a second analyst. Prior studies have found a strong correlation between CT-measured muscle density and intramuscular lipid by muscle biopsy (22, 24).

Physical Function Measures

Physical function outcomes included 3 different function outcomes: 10 repeat chair stands (lower extremity strength), grip strength (upper extremity strength), and a 4 meter timed walk at usual speed (composite function). Grip strength was determined using the average of three measures in the dominant hand with a Jamar® hydraulic handheld dynamometer. Walking speed was defined by the faster of two measurements at a "normal, comfortable pace" over a 4-meter course. Frailty was defined by the presence of 3 or more of the following: weak grip (grip strength < 20th percentile of HIV uninfected participants), slow gait (slower than 80th percentile of HIV uninfected participants), unintentional weight loss of ≥10 pounds, low activity (health limits a lot in vigorous activities), and exhaustion (work/activity difficulty due to physical health all or some of the time). Falls were assessed by a questionnaire beginning in 2014 in WIHS and MACS. Participants were asked to report any history of fall within the prior 6 months where fall was defined as: "an unexpected event, including a slip or trip, in which you lost your balance and landed on the floor, ground or lower level, or hit an object like a table or chair" (25). In subsequent semi-annual study visits, participants were asked if they had sustained a fall since the last visit.

Body mass index (BMI) categories included underweight/normal (<25.0 kg/m^2), overweight (25.0-29.9 kg/m^2), obese (≥30 kg/m^2). Sarcopenia was defined as grip/BMI <1.05 for men and <0.79 for women or as maximum grip <35.5 kg for men and <20 kg for women (26).

Statistical Analyses

Trunk muscle values used in analyses were the mean of the right and left muscle area/density measurements, while thigh values were from the right thigh only. Medians and interquartile ranges were calculated for muscle measurements and continuous variables. Frequencies and percentages were determined for categorical variables. Variables affecting muscle density and area were chosen a priori based on known associations in the general literature (22, 27, 28), so that the independent effect of HIV serostatus on muscle could be assessed. Outcomes were analyzed by generalized linear model (GLM), and included age, sex, race/ethnicity, BMI, and HIV serostatus. The association of muscle area/density with physical function measures was also analyzed using GLM. All statistical analyses were performed using SAS 9.4 (SAS Institute Inc, Cary NC).

Table 1. Baseline Characteristics

	Men			Women		
	Without HIV	With HIV	P value	Without HIV	With HIV	P value
N	189	197		64	119	
Age (years)	60 (55,64)	60 (54,63)	0.16	50 (45,53)	50 (47,53)	0.14
Race			0.05			0.92
White	157 (83)	145 (74)		11 (17)	21 (18)	
Black	30 (16)	50 (25)		41 (64)	73 (61)	
Other	2 (1)	2 (1)		12 (19)	25 (21)	
Hispanic Ethnicity	7 (4)	9 (5)	0.67	18 (28)	30 (25)	0.67
Smoking Status			0.89			0.01
Nonsmoker	62 (33)	67 (34)		9 (14)	14 (12)	
Former	95 (51)	95 (49)		13 (20)	51 (43)	
Current	29 (16)	33 (17)		42 (66)	54 (45)	
CD4+ T cell count (cells/μL)	-	642 (500, 826)		-	556 (381,756)	
HIV-1 RNA < 200 copies/mL	-	189 (96)		-	90 (76)	
Body Mass Index (kg/m2)			0.32			0.13
<25	87 (46)	91 (46)		12 (19)	32 (27)	
25-29	60 (32)	73 (37)		17 (27)	39 (33)	
30+	42 (22)	33 (17)		35 (55)	46 (39)	
Sarcopenia by grip strength/body mass index1	35 (19)	33 (17)	0.66	16 (34)	33 (36)	0.80
Sarcopenia by grip strength2	58 (31)	56 (29)	0.67	4 (7)	9 (9)	0.75

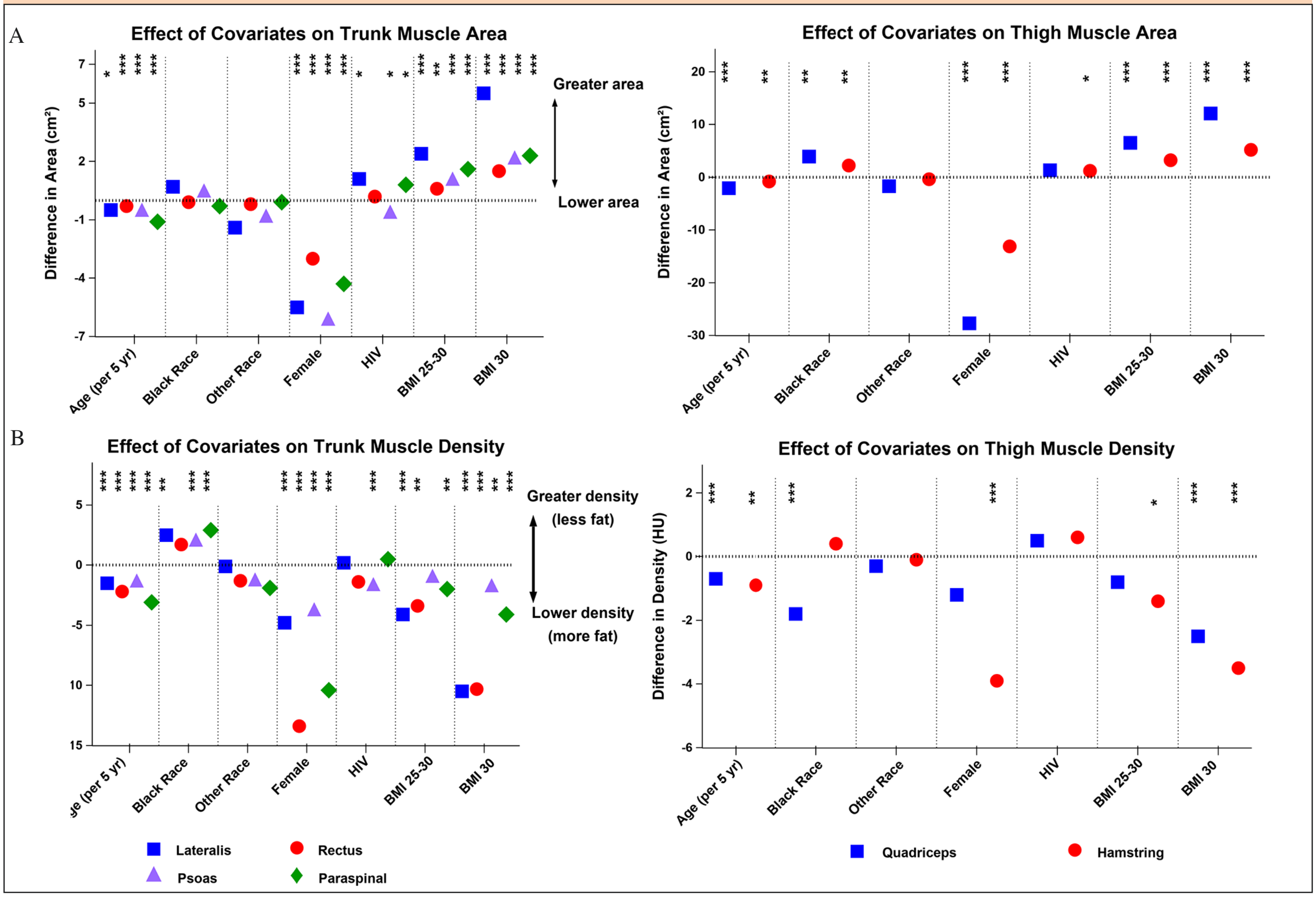
Values represent n (%) or median (interquartile range); 1. Sarcopenia defined by grip strength/body mass index is <1.05 for men and <0.79 for women; 2. Sarcopenia defined by maximum grip strength of <35.5 kg for men and <20 kg for women

Table 2. Baseline Muscle Area, Density, and Physical Function

Muscle Area and Density	Men without HIV (n=189)	Men with HIV (n=197)	Women without HIV (n=64)	Women with HIV (n=119)
Trunk Musculature Area and Density				
Lateralis Area	39.0 (35.1,43.4)	40.7 (35.1,45.2)	37.4 (31.7,41.4)	38.1 (32.7,42.5)
Rectus Area	50.0 (47.3,52.3)	50.7 (47.1,53.1)	49.2 (46.3,51.5)	49.6 (46.4,52.2)
Psoas Area	30.0 (23.4,36.5)	31.8 (24.9,35.9)	26.8 (20.1,33.6)	29.2 (22.1,35.5)
Spinalis Area	29.6 (20.7,37.9)	29.6 (18.6,35.1)	16.0 (9.5,28.1)	20.8 (10.9,29.3)
Lateralis Density	32.4 (27.7,36.2)	33.5 (29.8,38.0)	25.0 (20.0,27.6)	24.2 (18.9,29.5)
Rectus Density	70.6 (63.3,77.6)	70.7 (62.8,80.8)	52.7 (47.3,58.7)	53.2 (47.4,60.7)
Psoas Density	41.9 (39.0,45.4)	41.8 (36.7,44.7)	42.2 (38.6,45.8)	41.5 (38.0,44.4)
Spinalis Density	22.3 (18.4,25.8)	24.1 (20.4,28.2)	20.9 (18.0,24.5)	19.7 (16.9,24.4)
Thigh Musculature Area and Density				
Hamstring Area	32.4 (27.7,36.2)	33.5 (29.8,38.0)	25.0 (20.0,27.6)	24.2 (18.9,29.5)
Quad Area	70.6 (63.3,77.6)	70.7 (62.8,80.8)	52.7 (47.3,58.7)	53.2 (47.4,60.7)
Hamstring Density	39.0 (35.1,43.4)	40.7 (35.1,45.2)	37.4 (31.7,41.4)	38.1 (32.7,42.5)
Quad Density	50.0 (47.3,52.3)	50.7 (47.1,53.1)	49.2 (46.3,51.5)	49.6 (46.4,52.2)
Physical Function				
Gait speed (m/s)	1.1 (1.0, 1.2)	1.1 (1.0,1.2)	0.9 (0.8,1.0)	1.0 (0.8,1.1)
Grip strength (kg)	37 (31.0, 43.0)	37 (31.0,42.0)	28 (20.0,32.0)	28 (21.0,31.0)
10x chair rise (seconds)	20.2 (17.3,28.2)	21.7 (17.8,26.0)	24.3 (21.4,27.7)	23.8 (19.6,28.6)
Frailty	9 (5.7)	26 (16.2)	7 (13.7)	12 (12.4)
Fall in prior 6 months (%)	81 (43.3)	83 (43.7)	27 (44.3)	49 (42.2)

Values are presented as median (interquartile range) or frequency (percentage). Units for area are in centimeters2 and units for density in Hounsfield units (HU).

Figure 1. The association of covariates on difference in trunk (1A) or thigh (1B) muscle area and density (Y axis) using regression models



Confidence intervals are provided in the supplemental materials. * p<0.05; ** p< 0.01; *** p<0.001

The GLM parameter estimates for muscle area/density with physical function measures (adjusted for age, race, race/ethnicity, and BMI) stratified by HIV serostatus and sex were imported into RStudio Version 1.2.5019 (RStudio, PBC, Boston, MA). Rearrangement of the data was done using the melt function of the reshape package (v0.8.8) (29). Heat maps were created with ggplot function of the ggplot2 package (v3.3.5; Wickham, 2016) (30).

Results

CT scans were available on 387 men (198 with HIV) and 184 women (118 with HIV). Among men, the mean age was 64 years, 21% were Black, 13% current smokers, and 19% were obese. Among women, mean age was 50 years, 63% were Black, 53% current smokers, and 44% were obese. All participants with HIV were receiving ART. Study population characteristics are shown in Table 1. Trunk muscle area and density and thigh muscle area and density are shown in Table 2.

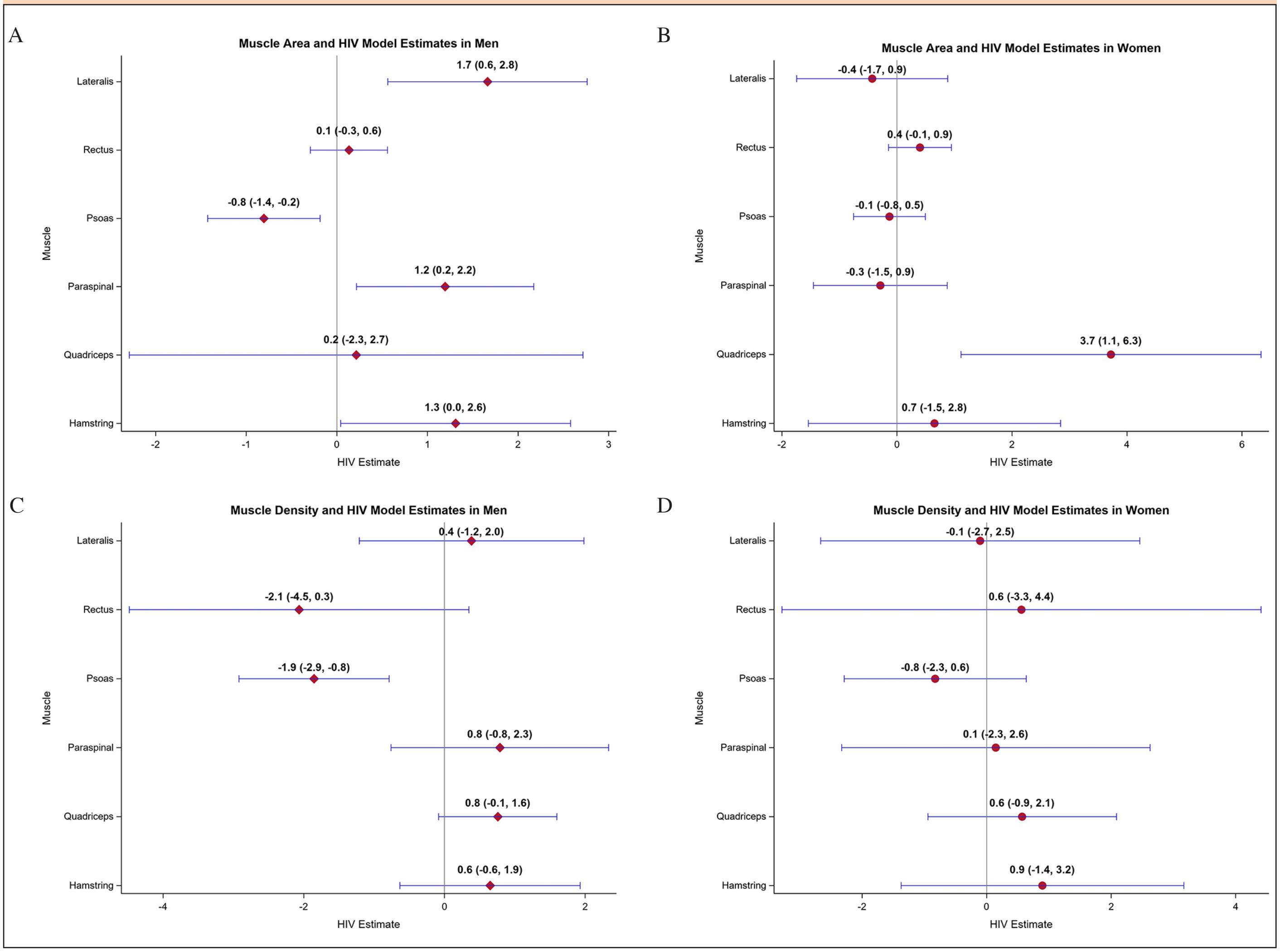
Trunk Muscle Area

Overall, HIV serostatus was associated with greater lateralis and paraspinal but lower psoas area. Older age and female sex were associated with smaller trunk muscle area in all muscles, while obesity was associated with greater trunk muscle area. (Figure 1A; Supplemental Table 1A and 1B). In sex-stratified models, HIV serostatus was associated with greater lateralis, psoas, and paraspinal muscle area only in men (Figure 2A and 2B; Supplemental Table 2A).

Trunk Muscle Density

HIV serostatus was associated only with lower psoas density (Figure 1B, Supplemental Table 1B). Older age, female sex, and obesity were associated with lower muscle density in all 4 muscle groups; Black race was associated with greater muscle density in 3 of the trunk muscle groups. In sex-stratified models, HIV serostatus was associated with significantly lower psoas density among the men (-1.9 [CI -2.8, -0.7] HU, p=0.001) but not among women (-0.8 [CI -2.3, 0.6] HU, p=0.27); Figures 2C and 2D; Supplemental Table 2B.

Figure 2. Differences by HIV serostatus on muscle area in men (2A) and women (2B) and muscle density in men (2C) and women (2D)



Models were adjusted for age, race/ethnicity, and body mass index.

Thigh Muscle Area

HIV serostatus was associated with greater hamstring but not quadriceps area. Older age, female sex, non-black race, and non-overweight/obese BMI were associated with significantly lower quadriceps and hamstring area (Figure 1A; Supplemental Table 1). In sex-stratified models, positive HIV serostatus was independently associated with greater quadriceps area among women (3.7 [1.1, 6.3], p=0.005) and greater hamstring area among men (1.3 [0.01, 2.5], p=0.048); Figures 2A and 2B; Supplemental Table 2C.

Thigh Muscle Density

No HIV serostatus effect was seen in combined (Figure 1B) or sex-stratified (Figure 2C and 2D) models, with the exception of lower psoas density among men with HIV only. Among all participants, older age, black race, and obesity were associated with lower quadriceps density. Similarly, older age, female sex, and being both overweight or obese were associated with lower hamstring density (Figure 1B, Supplemental Table 1B).

Association between Muscle Area and Physical Function

Next, we explored the association of muscle area and density with physical function in models stratified by sex and adjusted for age, race, BMI, and HIV serostatus (Supplemental Table 3). Among women, greater psoas and paraspinal muscle area were associated with stronger grip, but we found no association of trunk muscle area with gait or chair rise time. Greater thigh musculature area was associated with faster gait speed, stronger grip, and faster chair rise time (hamstring only). Among men, trunk and thigh muscle area were associated with stronger grip, but not faster gait speed or chair rise time. Differences were apparent by HIV serostatus and sex, as shown in Figure 3. Greater trunk muscle area was associated with faster chair rise time in both women and men with HIV, and with stronger grip in women with or without HIV and men with HIV. Greater quadriceps and hamstring area were associated with stronger grip in both women and men with HIV. Greater hamstring area was associated with faster gait speed in women with HIV and faster chair rise in men with HIV.

Association between Muscle Density and Physical Function

In adjusted models stratified by sex, greater psoas density was associated with faster chair rise time (p=0.006) among women; no associations were detected between muscle density of other trunk or thigh muscles on gait speed, grip strength, or chair rise time among women. In contrast, among men, greater density of nearly all of the trunk and thigh musculature were associated with faster gait speed, stronger grip, and faster chair rise time (Supplemental Table 3). In heat maps (Figures 3A, 3B, 3C) stratified by HIV serostatus and sex, we found relatively few associations of muscle density with physical function among women with or without HIV; an exception was that greater quadriceps density was associated with faster chair rise time in women without HIV. Among men, greater density of the trunk (psoas and paraspinal) muscles were associated with stronger grip in men with HIV and greater density of trunk (psoas, paraspinal and lateralis) muscles with faster chair rise time among men without HIV. Similar associations were seen with other muscle groups, but did not reach statistical significance. Greater quadriceps density was associated with faster chair rise time in men both with and without HIV. Similarly, greater hamstring density was associated with faster chair rise time and gait speed among men without HIV (Supplemental Table 3).

Association between Muscle Density and Area and Frailty

In adjusted models stratified by sex, greater area of the rectus, psoas, quadriceps, and hamstring were associated with a lower odds of frailty, while only the quadriceps density was associated with lower odds of frailty among women (all $p<0.05$). In contrast, among men, only a greater psoas area was associated with lower odds of frailty, while a greater density of all muscles was associated with lower odds of frailty (all $p<0.05$). As shown in Figure 3D, in general, density was more strongly associated with a lower odds of frailty among the men, especially those with HIV, and among women with HIV but only at the thigh. In contrast, muscle area was associated with lower frailty among women both with (thigh) and without HIV (trunk), and in select muscle groups among men.

Association between Muscle Density and Area and Falls

Lastly, we explored the association of muscle density and area with falls. The odds of falling were lower with greater hamstring density in women (OR 0.94, CI 0.9-1.0, p=0.008) and men (OR 0.97, 0.9, 1.0; p=0.061). No significant associations existed between trunk muscle density or area with falls.

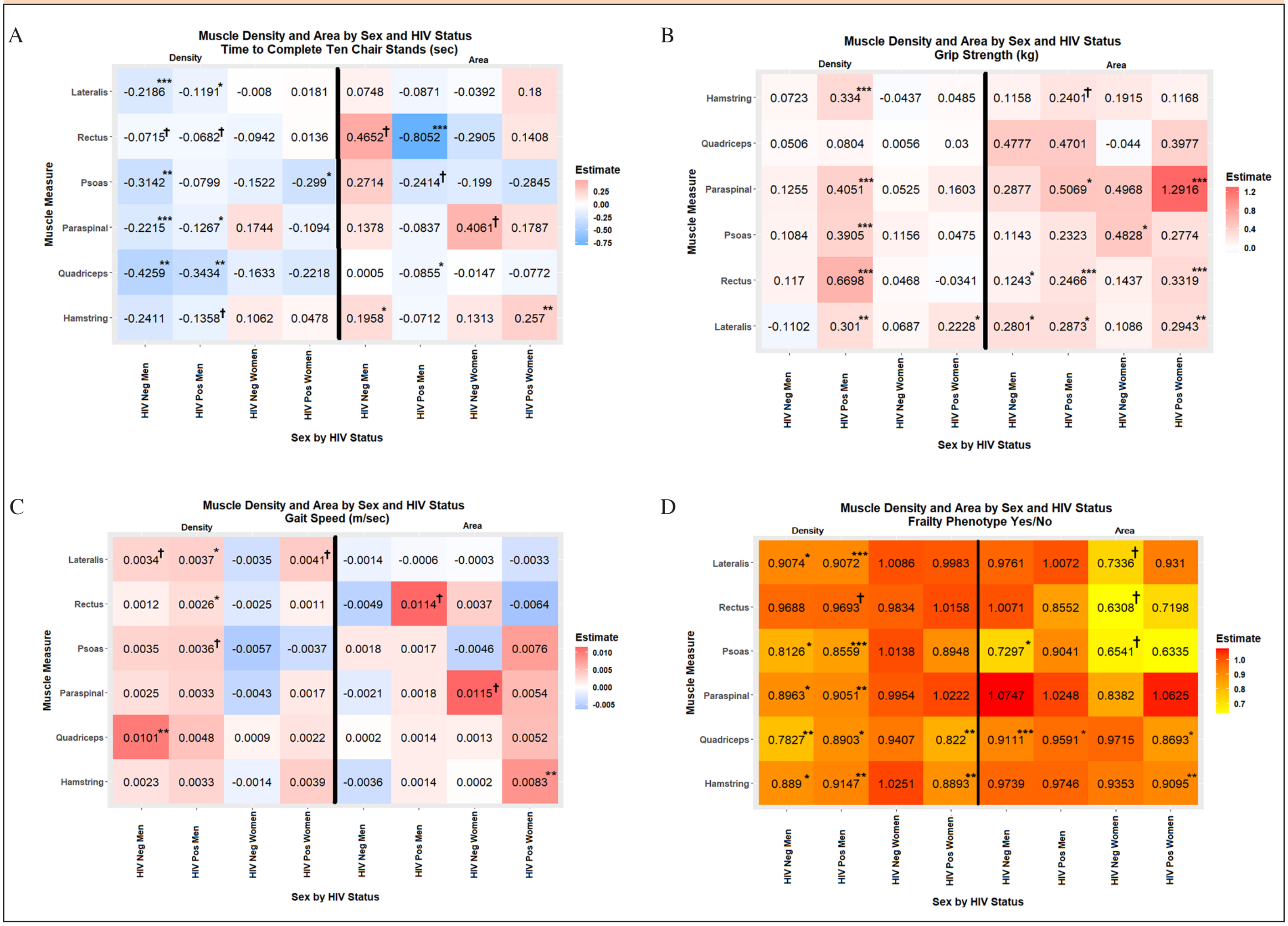
Discussion

In this large, well-characterized cohort of men and women with and without HIV, we explored the associations of HIV serostatus on both trunk and thigh muscle area and muscle density. Positive HIV serostatus was associated with smaller, less dense psoas but slightly larger and leaner thigh muscles. Women, regardless of HIV serostatus, tended to have smaller, less dense trunk and thigh muscle. Furthermore, many of these measures of muscle quantity and quality had functional implications among women and men, with and without HIV.

First, in regard to muscle area, we expected to see a strong HIV effect across most muscle areas, but in contrast to our hypothesis, only the psoas muscle area was smaller among PWH. Furthermore, women with HIV actually had greater quadriceps area than women without HIV, even after adjusting for BMI, though as below, we found that this appears to be fatty, low density muscle. In contrast, in a separate MACS substudy population, men with HIV had smaller thigh muscle area (trunk muscles not assessed), though this population was younger and included only men[18]. In the FRAM cohort, men but not women with HIV had lower regional skeletal muscle by MRI at baseline compared to controls; both men and women had similar changes over time regardless of HIV serostatus after accounting for cohort differences, though participants were considerably younger than the current cohort (31). Other studies have found considerably faster decline in lean body mass measured by DXA among PWH compared to persons without HIV, though DXA-based measures may have been confounded by differences in organ mass that contribute to lean mass and unmeasured confounders that differed between groups (physical activity) (3). At the tissue level, a previously published study demonstrated that PWH had a gene signature suggestive of skeletal muscle fibrosis with aging, which might also contribute to smaller muscle area with aging (32).

We also expected to see a stronger association between HIV serostatus and muscle density, particularly with the combination of ART, age, and body fat changes associated with HIV in these cohorts. However, we saw significant HIV associations only in the psoas, particularly in the men, where lower density (fattier) psoas (mean -1.9 HU) was observed and, based on Table 2, may have impact physical function and frailty. To account for potential associations with fat location, we also substituted VAT or SAT for BMI (data not shown), with minimal effect apparent. In a prior MACS analysis involving a different substudy, men with HIV had lower thigh muscle density compared to men without HIV (18). As we recently published, muscle density decreased across all trunk muscles in the period following ART initiation (33), however participants in the current analysis were considerably older with a longer duration of ART use compared to the ART initiation study. Torriani, et al found greater fat by MRI-based imaging within the calf muscles among women with HIV with and without lipodystrophy compared to women without HIV though, similarly, the participants with HIV were included specifically because of lipodystrophy (34). With general obesity and age-associations in the current HIV era, rather than lipodystrophy

Figure 3. Associations between of muscle density and area on chair rise (3A), grip strength (3B), gait speed (3C), and odds of frailty (3D) stratified by HIV serostatus and sex



Models are adjusted for age, race/ethnicity, and body mass index. † indicates p <0.10; * p<0.05; ** p< 0.01; *** p<0.001

and ART-related associations, the independent HIV effect on muscle fat appear to be less apparent.

Other than HIV associations, we found that older age and female sex were associated with smaller but less dense trunk and thigh musculature, while obesity was associated with less dense but larger trunk and thigh muscle area. Trunk and thigh density were primary driven by those factors previously described in the literature: age, sex, race, and BMI (22, 28). As recently summarized, across nearly all studies, greater muscle fat is strongly associated with increasing age, and women tend to have greater muscle fat independent of BMI or total body fat (27).

Our findings of the impact of muscle density and area on physical function, frailty, and falls in these two cohorts are of great clinical relevance for aging PWH. The psoas plays a key role in hip flexion and trunk stabilization, important in daily movements such as sitting, walking, posture, and balance. Indeed, we found that greater psoas density (less fat) was associated with faster gait speed, stronger grip strength, faster time to rise from a chair (more apparent in men), and lower odds of frailty supporting the clinical impact of the smaller and less dense muscle on physical function among PWH. Overall, larger muscle area was associated with better physical function among both women and men, though associations with frailty were more apparent among the women. Conversely, associations between muscle density with physical function and frailty were more apparent among the men in our cohort, with the exception of an association between psoas density and chair rise and quadriceps density and frailty in women with HIV. The men were considerably older than women (60 vs 50 years), thus our findings of muscle density and physical function among the men only may reflect the age-related associations, with muscle density impacting physical function more among older individuals. Indeed, a recent consensus meeting on myosteatosis noted that muscle fat may be a more consistent signature of aging than traditional sarcopenia (loss of muscle area), particularly as weight fluctuations may have a stronger effect on area (27).

The major strengths of this study are the inclusion of measures of muscle area, density, and function, a demographically similar control population without HIV, and inclusion of both men and women. The smaller number of women with available CT data may have limited our ability to detect meaningful associations among women. Physical activity may have an important influence on muscle area and density, but was assessed only with self-report and not consistently collected in both cohorts, so we were not able to adequately evaluate this confounder. Similarly, with our sample size, we were unable to adjust for many other potentially confounding variables. While our cohort captured an age range, very few of the participants were over age 75, thus limiting an understanding of age effects. CT-based measures of density were simply an estimate, and were not confirmed with muscle biopsy.

In summary, older adults with HIV may have smaller and less dense muscles, particularly the psoas, compared to demographically similar older adults without HIV. Differences by sex are apparent, though may be due to differing demographic factors of the two cohorts. These changes in muscle quantity and quality can have important implications on physical function with aging. The longitudinal associations of muscle area and density with physical function require careful investigation, with a particular focus on characteristics and interventions that can preserve muscle area, density, and function over time.

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