

The association between baseline body mass index (BMI) and viral suppression, CD4 recovery and viral rebound among people living with HIV: the Canadian HIV Observational Cohort (CANOC)

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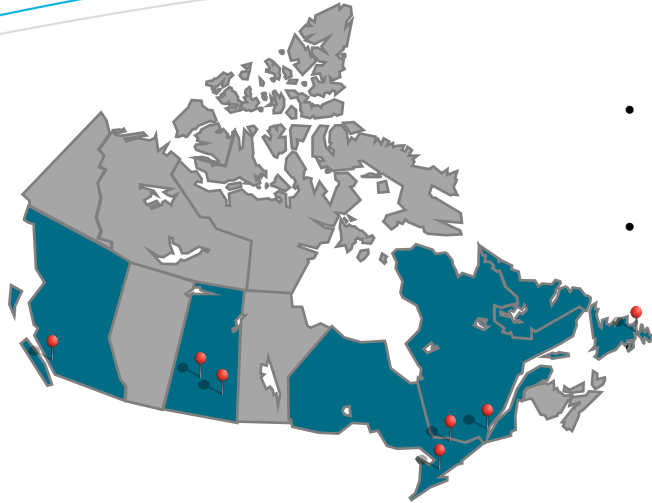
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Background



- The association between Body mass index (BMI) and viral load (VL) suppression and rebound, and CD4 recovery among people living with HIV remains inconclusive.^{1,2}
- Some studies have suggested individuals with a higher BMI experience better virological and immune response, and that immune response among overweight males is attenuated compared to overweight females.³

This study explored the association of baseline BMI with time to VL suppression, CD4 rebound and VL rebound among PLHIV, stratified by sex in the Canadian HIV Observational Cohort (CANOC) Collaboration

Methods

- The Canadian HIV Observational Cohort (CANOC) includes ART-naïve individuals initiating combined antiretroviral therapy (cART) between 2000 and 2016
- Study inclusion criteria: ≥ 18 years with ≥ 12 months clinical follow up, baseline CD4 and VL recordings and ≥ 2 consecutive follow-up CD4 and VL measurements
- BMI was recorded within 90-days before or after cART initiation and stratified into underweight (< 18.5 kg/m²), normal (18.5-24.9 kg/m²), overweight (25-25.9 kg/m²), obese (> 30 kg/m²) and no BMI recording
- VL suppression was defined as ≥ 2 consecutive VL measures < 200 copies/mL; CD4 recovery was defined as switch from non-normal range to normal range (410-1500 cells/mm³) with a CD4 increase > 50 cells/mm³; VL rebound was defined as ≥ 2 consecutive VL measures > 200 copies/mL after VL suppression
- Multivariable cox proportional hazards modelling was conducted to examine associations overall and by sex and adjusted hazard ratios and 95% confidence intervals were reported



Table 1. Baseline characteristics

Variable	Baseline BMI				
	Underweight ($< 18.5 \text{ kg/m}^2$)	Normal ($18.5\text{-}24.9 \text{ kg/m}^2$)	Overweight ($25\text{-}29.9 \text{ kg/m}^2$)	Obese ($> 30 \text{ kg/m}^2$)	No BMI recording
	N=207	N=1930	N=962	N=314	N=7825
	N (%)	N (%)	N (%)	N (%)	N (%)
Achieved viral suppression					
Yes	197 (95)	1863 (97)	938 (98)	310 (99)	7548 (96)
No	10 (5)	67 (3)	24 (2)	4 (1)	277 (4)
Experienced viral rebound after suppressing					
Yes	58 (29)	383 (21)	135 (14)	52 (17)	1402 (19)
No	139 (71)	1480 (79)	803 (86)	258 (83)	6146 (81)
Immune recovery					
Yes	204 (99)	1888 (98)	943 (98)	308 (98)	7602 (97)
No	3 (1)	42 (2)	19 (2)	6 (2)	223 (3)
Ever coinfectd with Hep C					
Yes	70 (34)	468 (24)	191 (20)	81 (26)	1899 (24)
No	134 (65)	1435 (74)	755 (78)	227 (72)	5498 (70)
Unknown	3 (1)	27 (1)	16 (2)	6 (2)	428 (5)
Ever diagnosed with AIDS-defining illness					
Yes	97 (47)	472 (24)	179 (19)	48 (15)	1512 (19)
No	110 (53)	1458 (76)	783 (81)	266 (85)	6313 (81)
Era of ART initiation					
2000-2003	39 (19)	309 (16)	123 (13)	42 (13)	1492 (19)
2004-2007	62 (30)	451 (23)	232 (24)	56 (18)	1789 (23)
2008-2011	61 (29)	646 (33)	334 (35)	102 (32)	2639 (34)
2012-2016	45 (22)	524 (27)	273 (28)	114 (36)	1905 (24)
ARV regimen type at initiation					
NNRTI	67 (32)	758 (39)	406 (42)	136 (43)	3359 (43)
PI	116 (56)	909 (47)	401 (42)	125 (40)	3364 (43)
IIN	14 (7)	197 (10)	123 (13)	43 (14)	805 (10)
Other	10 (5)	66 (3)	32 (3)	10 (3)	297 (4)
Neighbourhood level material deprivation at baseline					
Yes	63 (30)	511 (26)	262 (27)	99 (32)	2577 (33)
No	127 (61)	1311 (68)	656 (68)	201 (64)	4505 (58)
Unknown	17 (8)	108 (6)	44 (5)	14 (4)	743 (9)
	Median (Q1-Q3)	Median (Q1-Q3)	Median (Q1-Q3)	Median (Q1-Q3)	Median (Q1-Q3)
Age at first ARV initiation (yrs)	41 (33-47)	39 (32-47)	41 (34-48)	40 (34-48)	39 (32-46)
Baseline CD4 (cells/mm ³)	120 (30-230)	220 (104-340)	260 (161-376)	280 (180-400)	250 (140-380)
Baseline VL (Log ₁₀ copies/mL)	5 (4.76-5.00)	4.91 (4.39-5.00)	4.78 (4.21-5.00)	4.66 (3.99-5.00)	4.83 (4.34-5.00)

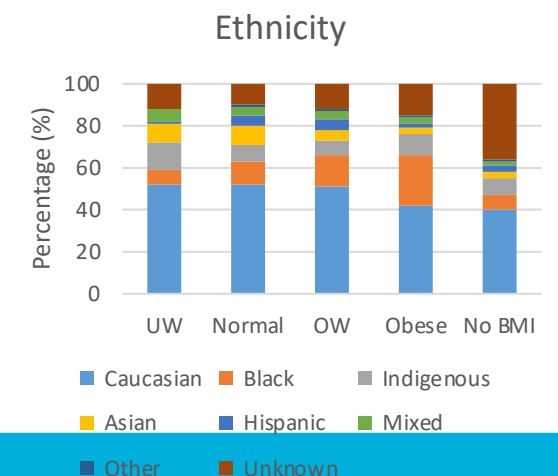
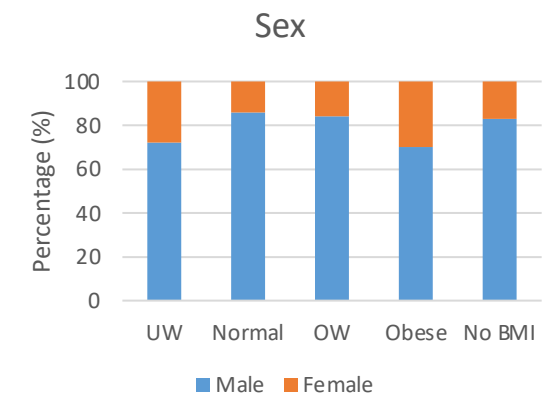
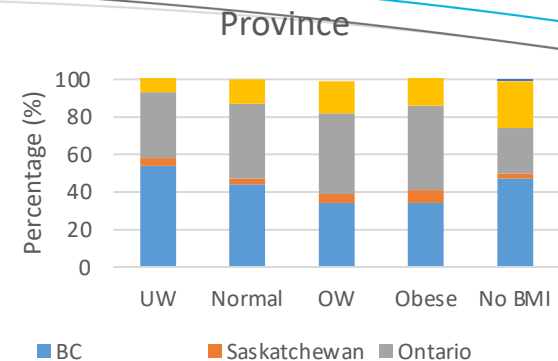




Table 2. Unadjusted and adjusted cox proportional hazard models for time to viral suppression, CD4 rebound and viral rebound by baseline BMI status, overall and among males and females.

	Overall		Males		Females	
	HR (95% CI)	aHR (95% CI)	HR (95% CI)	aHR (95% CI)	HR (95% CI)	aHR (95% CI)
Viral suppression*						
Normal	ref	ref	ref	ref	ref	ref
Underweight	0.86 (0.74-0.99)	0.93 (0.80-1.07)	0.98 (0.83-1.16)	1.08 (0.91-1.28)	0.74 (0.55-1.00)	0.83 (0.61-1.12)
Overweight	1.13 (1.04-1.22)	1.09 (1.01-1.18)	1.10 (1.01-1.20)	1.07 (0.98-1.16)	1.28 (1.04-1.56)	1.20 (0.98-1.48)
Obese	1.21 (1.08-1.37)	1.14 (1.01-1.29)	1.18 (1.03-1.36)	1.11 (0.96-1.27)	1.45 (1.14-1.85)	1.34 (1.05-1.70)
No BMI Recording	0.87 (0.82-0.91)	0.84 (0.79-0.88)	0.88 (0.83-0.93)	0.85 (0.80-0.90)	0.84 (0.73-0.96)	0.85 (0.75-0.98)
CD4 Recovery**						
Normal (ref)	ref	ref	ref	ref	ref	ref
Underweight	0.72 (0.60-0.86)	0.78 (0.66-0.94)	0.76 (0.62-0.93)	0.82 (0.67-1.01)	0.65 (0.46-0.94)	0.74 (0.52-1.06)
Overweight	1.16 (1.06-1.28)	1.11 (1.01-1.22)	1.19 (1.08-1.32)	1.15 (1.04-1.28)	1.04 (0.82-1.32)	0.94 (0.74-1.20)
Obese	1.05 (0.91-1.22)	0.95 (0.82-1.10)	1.05 (0.88-1.26)	0.97 (0.81-1.16)	1.12 (0.85-1.49)	1.01 (0.77-1.34)
No BMI Recording	0.89 (0.84-0.95)	0.85 (0.80-0.91)	0.91 (0.85-0.97)	0.89 (0.83-0.95)	0.83 (0.72-0.97)	0.87 (0.74-1.01)
Viral rebound***						
Normal (ref)	ref	ref	ref	ref	ref	ref
Underweight	1.45 (1.10-1.92)	1.10 (0.84-1.46)	1.32 (0.94-1.86)	1.09 (0.78-1.54)	1.42 (0.88-2.29)	1.31 (0.81-2.13)
Overweight	0.67 (0.55-0.82)	0.80 (0.65-0.97)	0.63 (0.50-0.79)	0.69 (0.55-0.86)	0.79 (0.54-1.16)	0.99 (0.68-1.46)
Obese	0.85 (0.80-1.00)	0.93 (0.70-1.25)	0.89 (0.62-1.26)	0.99 (0.69-1.40)	0.58 (0.35-0.98)	0.69 (0.41-1.17)
No BMI Recording	0.89 (0.80-1.00)	0.91 (0.81-1.02)	0.84 (0.73-0.95)	0.88 (0.77-1.00)	1.03 (0.82-1.31)	1.00 (0.79-1.27)

*Adjusted for ever diagnosed with ADI; baseline CD4

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***Adjusted for province, ever co-infected with Hep C, ever diagnosed with ADI, age at first ARV initiation overall

HR=Hazard ratio; CI Confidence interval; BMI=Body mass index

Discussion & Conclusion

- This research supports the findings of other studies that demonstrate individuals with a higher BMI experience better virological and immune response, and that sex may influence the association of baseline BMI and immune response
- We found obese women were more likely to achieve VL suppression compared to women with a normal baseline BMI, but this association was not seen among men, and overweight men were less likely to rebound after VL suppression compared to men with a normal baseline BMI, but this association was not seen among women
- BMI is likely one element in a multitude of inter-related factors that can influence virologic and immune response

Limitations

- Data from BC includes all known adults on cART, while data from Ontario, Saskatchewan, Quebec and Newfoundland is clinic based, and may therefore not include a representative sample of PLHIV in those provinces
- A large proportion of individuals had missing BMI information, which could be due to different clinic reporting practices, or a multitude of other socioeconomic or demographic factors.
- A possible reason for women to initiate cART may be pregnancy, however we do not have information on pregnancy in CANOC, so all women were included. A sensitivity analysis excluding women of reproductive age is planned.
- CANOC does not include information on adherence which may influence VL suppression and rebound.

Acknowledgements

- The authors would like to thank all participants of the CANOC Collaboration for their valued information. CANOC is supported by the Canadian Institutes of Health Research (CIHR) and by the CIHR Canadian HIV Trials Network: Centres Grant - Centres for HIV/AIDS Population Health and Health Services Research [CIHR #02684], two Operating Grants - HIV/AIDS Priority Announcement [CIHR #134047], Population and Public Health Grant [CIHR #136882], Foundation Grant - Expansion of Antiretroviral Therapy and its Impact on Vulnerable Populations in Canada and Global Settings [CIHR #143342], and CIHR Canadian HIV Trials Network [CTN #242]

References

1. Tedaldi EM, Brooks JT, Weidle PJ, Richardson JT, Baker RK, Buchacz K, et al. Increased Body Mass Index Does Not Alter Response to Initial Highly Active Antiretroviral Therapy in HIV-1-Infected Patients: JAIDS Journal of Acquired Immune Deficiency Syndromes. 2006 Sep;43(1):35–41.
2. Palermo B, Bosch RJ, Bennett K, Jacobson JM. Body mass index and CD4+ T-lymphocyte recovery in HIV-infected men with viral suppression on antiretroviral therapy. HIV Clinical Trials. 2011;
3. Koethe J, Jenkins C, Lau B, Shepherd B, Silverberg M, Brown T, et al. Body mass index and early CD4 T-cell recovery among adults initiating antiretroviral therapy in North America, 1998-2010: BMI and early CD4 T-cell recovery on ART. HIV Med. 2015 Oct;16(9):572–7