Cardiometabolic Multimorbidity and Activity Limitation in Canada: A Cross-Sectional Study of Adults Using the Canadian Longitudinal Study of Aging (CLSA) Data

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Research article

Keywords: Activities of daily living, Activity limitation, Aging, Canadian Longitudinal Study on Aging, Cardiometabolic multimorbidity, Diabetes, Disability, Multimorbidity, Myocardial infarction, Stroke

DOI: https://doi.org/10.21203/rs.3.rs-115170/v1

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Abstract

Background: Cardiometabolic multimorbidity (CM) is the diagnosis of at least two of: diabetes, stroke, or heart disease. CM is a common pattern of multimorbidity, however, the association between CM and activity limitation remains unknown. The objectives of this study were to 1) estimate the prevalence of activity limitations among Canadians with CM; and 2) quantify the association between CM and activity limitations.

Methods: Using data from the Canadian Longitudinal Study on Aging (CLSA), we estimated the prevalence of CM in Canadians aged 45 to 85 (n=51,022). Multinomial logistic regression was used to quantify the association between CM and activity limitation, evaluated using the Older American Resources and Services (OARS) scale.

Results: The prevalence of people living with CM and reporting any activity limitation was 27.4%, with the greatest proportion (47.9%) observed in participants living with all three cardiometabolic conditions. The multinomial odds ratio (or relative risk ratio (RRR)) of activity limitation was greatest amongst participants with all three CM conditions (any limitation: RRR = 11.229, 95% CI = 5.803 to 21.726). Of the two disease combinations, those that included stroke had the greatest odds of activity limitation (stroke and diabetes: RRR = 6.546, 95% CI = 4.436 – 9.661; stroke and myocardial infarction: RRR = 7.029, 95% CI = 4.168 – 11.853).

Conclusion: Activity limitation is common amongst Canadians living with CM, and those with CM have an increased odds of reporting activity limitation relative to those with no CM conditions. The odds increase in dose-response relationship as one accumulates more CM conditions.

Introduction

With an aging population, advancing life expectancy, and increasing numbers of people with individual chronic diseases, the prevalence of multimorbidity is increasing.\(^1\)–\(^3\) It is estimated that 40% of Canadians between the ages of 45–85 are living with three or more chronic conditions,\(^4\) with as many as 52% in 60 to 64 years of age range. In the United States, the prevalence of multimorbidity is as high as 70.6% in adults between the ages of 45 and 64, and 91.8% in those over 65 years of age.\(^5\) While the economic burden of multimorbidity is substantial, with costs ranging from 2.7 times\(^6\) to 5.3 times\(^7\) higher than the per person annual cost of those living with only one condition, the burden of multimorbidity on health and well-being is also considerable. Several studies have shown that those living with multimorbidity have more complications of treatment beyond the effects of individual conditions,\(^8\) lower quality of life,\(^9\)–\(^11\) psychological issues,\(^12\)\(^–\(^13\) increased healthcare use,\(^11\)\(^,\)\(^14\) and high levels of disability.\(^11\)\(^,\)\(^15\)

Cardiometabolic multimorbidity (CM) is a specific pattern of multimorbidity defined as the diagnosis of two or more of diabetes (DM), stroke, or myocardial infarction (MI).\(^16\)–\(^18\) Existing studies report a prevalence of CM ranging from 3% in adults over the age of 18,\(^19\) to 6% in older adults.\(^20\) Amongst Canadians, it is estimated that 3.5% (n = 467,749) of those over the age of 50 are living with CM,\(^21\) with another 18% (n = 2.38 million) reporting an individual cardiometabolic condition, and thus at high risk of developing CM.\(^21\)

Although CM is a common pattern of multimorbidity,\(^22\)–\(^27\) existing research and clinical guidelines traditionally focus on individual diseases while ignoring the additional complexities resulting from comorbid conditions.\(^28\)\(^,\)\(^29\) Thus, treatment recommendations that focus on individual conditions can result in fragmented, redundant, and often expensive care.\(^8\) Consequently, morbidity associated with CM are poorly understood clinically, which in turn has led to unmet health and rehabilitation needs. For example, existing, yet limited research, has shown that patients living with CM typically live with poor management of their conditions.\(^21\) Specifically, we have recently shown associations between cardiometabolic disease onset with lower levels of physical activity and more issues with stress management.\(^21\) Moreover, research indicates that people with CM are at higher risk of premature mortality and reduced life expectancy, compared to healthy individuals and those diagnosed with only one cardiometabolic condition.\(^16\)\(^,\)\(^18\)–\(^20\)\(^,\)\(^30\)\(^,\)\(^31\)

While research is beginning to develop an understanding of the health,\(^16\)–\(^20\)\(^,\)\(^30\) and lifestyle\(^21\) issues associated with CM, there remains a lack of understanding of the physical and functional complications associated with CM.\(^32\)–\(^37\) Disability often immediately precedes death, can have a profound impact on an individual’s quality of life, and is common sequelae after each of
stroke, heart disease, and diabetes. Therefore, addressing disability issues after cardiometabolic disease onset and developing a greater understanding of disability resulting from interacting cardiometabolic diseases is imperative given the increasing numbers of people with cardiometabolic diseases and CM.

Activity limitations are one of the most common forms of disability. Defined as the difficulties individuals have in their ability to execute a task or action, activity limitations are influenced by health condition and personal and environmental contextual factors, and have been shown to be predictive of a person's involvement in desired life situations and roles. Several recent studies have investigated associations between activity limitations and individual cardiometabolic diseases, showing limitations with physical activities and performing activities of daily living as compared to people without any cardiometabolic condition. While results of these studies generally indicate an increased risk of activity limitation with individual stroke, diabetes, or heart disease, no study has investigated the association of activity limitations among individuals with multiple cardiometabolic conditions.

Thus, the purpose of this population-based study is to examine activity limitation among people with CM. Our objectives are to: 1) estimate the prevalence and severity of activity limitations among Canadian adults with CM; and 2) quantify the association between individual cardiometabolic conditions and CM on activity limitations.

Methods

The reporting of the methods and results in this population-based cross-sectional study follows the Statistical Analyses and Methods in the Published Literature Guidelines.

Data source and study population

We used data from the Canadian Longitudinal Study on Aging (CLSA) to address our study objectives. The CLSA data set is a nationally representative sample of Canadians recruited using the Canadian Community Health Survey on Healthy Aging, provincial health registries, and random-digit dialing. Ethics approval for CLSA data collection was obtained by thirteen research ethics boards across Canada.

Baseline data from volunteer participants was collected between 2010 to 2015 and included two cohorts: 1) data collected using self-report questionnaires administered through 60-minute computer-assisted telephone interviews (n = 21,241), and 2) data collected at designated data collection sites or at the participant’s home (n = 30,097). For the purposes of this study, data from the cohorts were grouped as there was no difference in the variables of interest other than how the data was collected (Fig. 1). We included respondents between the ages of 45 and 85 who had data available for our dependent and independent variables. Excluded from the CLSA and thus our research, were residents in the three territories, persons living on federal First Nations reserves, full-time members of the Canadian Armed Forces, individuals living in institutions, and people who were not able to respond in English or French or who had cognitive impairment. Furthermore, individuals were excluded from our analysis if any one of the CM health conditions being assessed was unknown to the participant, if the participant refused to answer the question, or if the participant did not complete any variables included in this study (n = 316).

Variables

Activity Limitation (dependent variable) – Activity limitation was evaluated using the Older American Resources and Services (OARS) scale. This 14-item questionnaire assesses an individual's functioning with Activities of Daily Living (ADLs – dressing, feeding, appearance management, walking, getting out of bed, bathing, toileting) and Instrumental Activities of Daily Living (iADLs – telephone use, travel, shopping, meal preparation, housework, taking medication, finances). Item responses produce an unadjusted OARS score. For each ADL or iADL task included in the questionnaire, participants had three possible response options (able to complete the task, able to complete the task with assistance, unable to complete the task). One question regarding toileting asked if the participant had difficulty with incontinence and what was the frequency of the incontinence (never or less than once a week, once or twice a week, three times a week or more, don’t know/no answer, refused to answer).
To determine the level of activity limitation, participants were first assigned an ADL problem score based on the number of activities a participant identified as being able to complete with assistance (from the unadjusted OARS questionnaire) and the number of activities missing (no response provided by the participant). A participant’s ability to prepare their own meals was then considered in conjunction with the ADL problem score to determine their level of activity limitation, which was categorized as: no functional impairment, mild impairment, moderate impairment, severe impairment, total impairment. For the purposes of our analysis, the severe and total impairment categories were grouped. Table 1 outlines the process by which these variables were considered to determine activity limitation.

Table 1
– The classification of activity limitation using the OARS scale

| ADL problem score | Consideration of meal preparation | Activity Limitation Classification |
|-------------------|-----------------------------------|----------------------------------|
| 0 – None          | No help required to prepare own meals | 1 – No impairment |
| • Requires help with 0 activities and 0 missing values | | |
| 1 – Mild          | No help required to prepare own meals | 2 – Mild impairment |
| • Requires help with 1–3 activities and 0 missing values; or | | |
| • Requires help with 1–2 activities with 1 missing value; or | | |
| • Requires help with 1 activity with 2 missing values; | | |
| 2 – Moderate      | No consideration of help with meal preparation | 3 – Moderate impairment |
| • Requires help with 4–5 activities with 0 missing values; or | | |
| • Requires help with 4 activities with 1 missing value | | |
| 3 – Severe        | No consideration of help with meal preparation | 4 – Severe impairment |
| • Requires help with 6–7 activities with 0 missing values; or | | |
| • Requires help with 6 activities with 1 missing value | | |
| 4 – Total         | No consideration of help with meal preparation | 5 – Total impairment |
| • Requires help with 8–13 activities | | |
| Inconclusive Classification due to missing values | – | [Excluded from analysis] |
| • All other possible combinations | | |

*Health Condition (independent variable of interest)* – To determine a diagnosis of diabetes, heart attack, or stroke, participants were asked: 1) Has a doctor ever told you that you have diabetes, borderline diabetes or that your blood sugar is high? 2) Has a doctor ever told you that you have had a heart attack or myocardial infarction? 3) Has a doctor ever told you that you have experienced a stroke or a cerebrovascular accident? Participant responses were classified as: yes or no.

Respondents were divided into eight mutually exclusive groups. The control group included individuals reporting the absence of all of diabetes, myocardial infarction, and stroke. Three experimental groups were developed among those reporting single cardiometabolic diseases: 1) diabetes, 2) myocardial infarction, 3) stroke. Four additional experimental groups were also created for all possible cardiometabolic disease combinations: 1) Diabetes and Stroke, 2) Diabetes and Myocardial Infarction, 3) Stroke and Myocardial Infarction, 4) Diabetes and Stroke and Myocardial Infarction.
Contextual factor covariates – Environment: (i) Social support was measured using the 19-item Medical Outcomes Study (MOS): Social Support Survey. This valid and reliable questionnaire consists of four separate social support domains and scores (emotional/informational, tangible, affectionate, and positive social integration), as well as a composite social support index score. Each item is scored on a 5-point response scale (i.e., none of the time, a little of the time, some of the time, most of the time, all of the time). A mean total score is derived for each of the domains and for the composite score. We used the composite score in our analyses, in which higher scores indicate more social support. (ii) Rural or urban location of residence was identified via postal code data.

Personal: Demographic and socioeconomic variables included for study were age, biological sex (male/female), ethnic background (white, non-white), marital status (single, never married or never lived with a partner; married/living with a partner in a common-law relationship; widowed; divorced / separated), employment status (working, retired), household income (less than $20,000; $20,000 or more, but less than $50,000; $50,000 or more, but less than $100,000; $100,000 or more, but less than $150,000; $150,000 or more), and education (less than secondary school graduation; secondary school graduation, no post-secondary education; some post-secondary education; post-secondary degree/diploma).

Statistical Analyses

Weighted analysis was conducted for all analyses to ensure generalizability to the Canadian population and to account for the complex sampling method. Inflation weights were used in the descriptive analysis and analytic weights in the regression analysis, as per guidelines and weights provided by the CLSA.

Sample characteristics were described with the number and proportion for categorical variables and mean (SD) or median (interquartile range) for continuous variables, stratified by health condition(s) and presented as population estimates. The prevalence of activity limitations was estimated from the number of respondents reporting none, mild, moderate, severe/total activity limitation by diagnostic group, relative to the number of respondents in that group.

A series of logistic and multinomial logistic regression models were constructed to quantify the association between activity limitations (dependent variable) and cardiometabolic conditions (independent variable). In the logistic regression models, all levels of activity limitations were combined to report ‘any’ limitations vs ‘no’ limitations (i.e., ‘none’ base category). In the multinomial models, there were four categories of activity limitations, including: none (base category), mild, moderate, and severe/total combined. In both logistic and multinomial regression models, cardiometabolic condition was examined in eight mutually exclusive groups, as well as combination groups: any one CM health condition, any two CM health condition combinations, all three CM health conditions. For all models, no CM health condition was the base category. All models were adjusted for personal and environmental confounding variable, known to influence disability (i.e., age, sex, level of education, total household income, marital status, retirement status, rural/urban location, ethnicity, and the MOS scale of functional social support). Both unadjusted and adjusted multinomial odds ratios (reported as relative risk ratios (RRR)), along with 95% confidence intervals (CI), are reported.

All statistical analyses were completed using Stata S/E Version 15 software using the SVY commands for survey data analysis. All statistical tests were two-sided with alpha set at 0.05.

Results

Sociodemographic characteristics are presented in Table 2. A total of 46.8% of the sample population were men with an average age of 59.4 years. The proportion of men increased as cardiometabolic conditions accumulated, with 83.9% of those with all three conditions being men. More participants without CM reported the higher levels of education (74.35% having a post-secondary degree/diploma relative to 58.73% with CM). A total of 75.82% of participants without CM were married or living with a partner, relative to 65.88% of participants with CM.
| Disease Status                  | None          | Diabetes       | Myocardial Infarction | Stroke      | DM + MI | DM + ST | MI + ST | DM + MI + ST | Total          |
|--------------------------------|---------------|----------------|-----------------------|-------------|--------|--------|--------|-------------|----------------|
| Prevalence                     | 10,649,210    | 1,757,863      | 373,603               | 114,185     | 197,145| 48,582 | 27,373 | 16,555       | 13,184,516     |
| (80.77)                        | (13.33)       | (2.83)         | (0.87)                | (1.50)      | (0.37) | (0.21) | (0.13) | (100)        |
| Age                            |               |                |                       |             |        |        |        |              |                |
| Mean                           | 59.44         | 62.73          | 67.02                 | 66.57       | 66.99  | 65.86  | 68.48  | 68.30        | 60.32          |
| (SE)                           | (0.08)        | (0.19)         | (0.42)                | (0.77)      | (0.54) | (1.29) | (1.56) | (1.59)       | (0.07)         |
| Male sex                       | 4,987,847     | 881,190        | 264,099               | 59,022      | 133,280| 32,080 | 16,599 | 13,881       | 6,387,998      |
| (46.84)                        | (50.13)       | (70.69)        | (51.69)               | (51.69)     | (67.61)| (60.64)| (60.64) | (60.64)       | (48.45)        |
| Marital Status                 |               |                |                       |             |        |        |        |              |                |
| Single, never married or never lived with a partner | 820,000 | 148,209        | 26,959                | 9,023       | 15,725 | 7,772  | 3,819  | 1,984        | 1,033,491      |
| (7.70)                         | (8.43)        | (7.22)         | (7.90)                | (7.98)      | (16.00)| (13.95)| (11.99) | (7.84)        |
| Married/Living with a partner in a common-law relationship | 8,071,736 | 1,257,272      | 266,358               | 67,924      | 136,817| 26,684 | 16,160 | 9,848         | 9,854,800      |
| (75.82)                        | (71.52)       | (71.29)        | (59.49)               | (69.40)     | (59.04)| (59.04)| (59.49) | (74.77)       |
| Widowed                        | 699,731       | 153,413        | 42,836                | 15,246      | 21,284 | 5,890  | 4,589  | 2,398        | 945,387        |
| (6.57)                         | (8.73)        | (11.47)        | (13.35)               | (12.12)     | (16.76)| (14.49)| (14.76) | (7.17)        |
| Divorced / Separated           | 1,054,100     | 198,969        | 37,449                | 21,992      | 23,318 | 6,237  | 2,805  | 2,324        | 1,347,195      |
| (9.90)                         | (11.32)       | (10.02)        | (19.26)               | (11.83)     | (12.84)| (10.25)| (14.04) | (10.22)       |
| Education – Highest Level Achieved |            |                |                       |             |        |        |        |              |                |
| Less than secondary school graduation | 659,023 | 190,033        | 47,838                | 12,816      | 28,333 | 4,397  | 4,653  | 4,255        | 951,347        |
| (6.21)                         | (10.87)       | (12.90)        | (11.36)               | (14.40)     | (9.08) | (17.00)| (25.70) | (7.24)        |
| Secondary school graduation, no post-secondary education | 1,292,525 | 246,932        | 54,281                | 18,338      | 33,518 | 5,830  | 6,082  | 2,750         | 1,659,256      |
| (12.16)                        | (14.12)       | (14.63)        | (16.25)               | (17.04)     | (12.04)| (22.22)| (16.61) | (12.63)       |
| Some post-secondary education  | 772,794       | 149,498        | 34,013                | 7,838       | 22,308 | 2,876  | 2,533  | 1,754        | 993,614        |
| (7.28)                         | (8.55)        | (9.17)         | (6.95)                | (11.34)     | (5.94) | (9.25) | (10.60) | (7.56)        |
| Post-secondary degree/diploma  | 7,893,947     | 1,162,492      | 234,785               | 73,852      | 112,531| 35,332 | 14,104 | 7,796        | 9,534,839      |
| (74.35)                        | (66.47)       | (63.30)        | (65.45)               | (57.21)     | (72.95)| (51.53)| (47.09) | (72.57)       |
| Urban                          | 7,818,497     | 1,302,207      | 280,942               | 85,810      | 140,189| 35,651 | 20,888 | 11,318       | 9,695,501      |
| (77.40)                        | (78.10)       | (80.09)        | (77.25)               | (74.96)     | (79.69)| (82.01)| (74.03) | (77.54)       |

Unless otherwise specified, all values reported as: n (%); n = calculated using CLSA sampling weights; DM = diabetes mellitus; MI = myocardial infarction; ST = stroke
| Disease Status          | None | Diabetes | Myocardial Infarction | Stroke | DM + MI | DM + ST | MI + ST | DM + MI + ST | Total |
|------------------------|------|----------|-----------------------|--------|---------|---------|---------|--------------|-------|
| **Total Household Income** |      |          |                       |        |         |         |         |              |       |
| Less than $20,000      | 448,620 (4.44) | 125,234 (7.55) | 22,223 (6.31) | 18,866 (18.20) | 22,515 (12.25) | 4,456 (9.92) | 5,248 (20.46) | 2,709 (18.35) | 649,870 (5.21) |
| $20,000 – $50,000     | 2,133,222 (21.12) | 521,168 (31.42) | 131,728 (37.39) | 30,589 (29.51) | 67,749 (36.86) | 17,189 (38.27) | 12,111 (47.22) | 6,735 (45.62) | 2,920,490 (23.39) |
| $50,000 – $100,000    | 3,665,735 (36.29) | 584,274 (35.23) | 127,396 (36.16) | 35,862 (34.60) | 62,043 (33.76) | 18,098 (40.30) | 6,255 (24.38) | 3,294 (22.31) | 4,502,955 (36.07) |
| $100,000 – $150,000   | 2,080,859 (20.60) | 255,903 (15.43) | 42,320 (12.01) | 13,244 (12.78) | 21,434 (11.66) | 3,750 (8.35) | 1,186 (4.63) | 447 (3.03) | 2,419,142 (19.38) |
| $150,000 or more       | 1,771,441 (17.54) | 171,898 (10.36) | 28,642 (8.13) | 5085 (1.54) | 149,794 (40.42) | 10,035 (28.07) | 1,578 (4.63) | 1,990,948 (15.95) |
| **Retirement Status**  |      |          |                       |        |         |         |         |              |       |
| Working                | 6,860,055 (64.68) | 903,101 (51.52) | 149,794 (40.42) | 39,475 (35.06) | 81,074 (41.41) | 19,389 (39.93) | 7,079 (25.86) | 5,170 (33.54) | 8,065,137 (61.43) |
| Retired                | 3,745,899 (35.32) | 849,926 (48.48) | 220,843 (59.58) | 73,119 (64.94) | 114,703 (58.59) | 29,171 (60.07) | 20,294 (74.14) | 10,243 (66.46) | 5,064,198 (38.57) |
| **Cultural Background** |      |          |                       |        |         |         |         |              |       |
| White                  | 10,121,369 (96.10) | 1,629,167 (93.94) | 352,045 (96.17) | 109,919 (97.07) | 182,937 (95.17) | 26,160 (95.63) | 15,175 (91.73) | 12,480,764 (95.71) |
| Non-white              | 410,960 (3.90) | 105,178 (6.06) | 14,036 (3.83) | 3,316 (2.93) | 9,284 (3.16) | 2,108 (4.37) | 1,369 (8.27) | 549,641 (4.22) |
| **MOS Score – Functional Social Support** |      |          |                       |        |         |         |         |              |       |
| Low                    | 4,474,207 (43.53) | 840,551 (50.14) | 173,456 (48.03) | 59,452 (54.62) | 90,292 (49.04) | 29,535 (65.14) | 10,762 (45.40) | 8,072 (52.76) | 5,686,328 (44.80) |
| High                   | 5,804,383 (56.47) | 835,824 (49.86) | 187,722 (51.97) | 49,388 (45.38) | 93,814 (50.96) | 15,807 (34.86) | 12,941 (54.60) | 7,229 (47.24) | 7,007,108 (55.20) |

Unless otherwise specified, all values reported as: n (%); n = calculated using CLSA sampling weights; DM = diabetes mellitus; MI = myocardial infarction; ST = stroke

**Objective 1: Prevalence and severity of activity limitations among Canadian adults with CM**

The proportion of people reporting activity limitation decreased with increasing severity levels, as shown in Table 2. Those that reported a stroke showed the greatest proportion of participants living with any activity limitation (28% of all participants that
suffered a stroke). Overall, 27.4% of all participants living with CM reported some level of activity limitation (mild, moderate, or severe/total). Participants reporting all three conditions (stroke, myocardial infarction and diabetes) showed the greatest proportion of any activity limitation (47.9%).

Objective 2: Activity limitations and cardiometabolic conditions

Participants with one cardiometabolic condition were observed to have an increased odds of reporting mild to moderate activity limitations compared to individuals with no cardiometabolic condition, as shown in Table 3. Individuals with stroke alone had a greater odds of reporting activity limitation than individuals with only a myocardial infarction or diabetes at all three severities of activity limitation – mild, moderate, and severe/total (RRR: 2.72 [95% CI = 2.017 to 3.667], 7.20 [95% CI = 4.174 to 12.430], 10.68 [95% CI = 4.802 to 23.738], respectively).
Table 3
Multinomial logistic regression predicting the likelihood of activities disability (OARS)

| Activity Limitation Classification | None          | Mild          | Moderate      | Severe / Total | Any Limitation |
|-----------------------------------|---------------|---------------|---------------|----------------|----------------|
| No cardiometabolic condition      | 9,810,750 (92.52) | 718,326 (6.77) | 54,669 (0.52) | 20,569 (0.19) | 793,564 (7.48) |
| n (%)                             |               |               |               |                |                |
| One cardiometabolic condition     | 1,864,209 (83.6) | 308,710 (13.8) | 40,498 (1.8)  | 17,689 (0.8)  | 366,897 (16.4) |
| n (%)                             |               |               |               |                |                |
| DM only                           | 1,462,126 (83.6) | 248,333 (14.2) | 26,856 (1.5)  | 10,992 (0.6)  | 286,180 (16.4) |
| RRR (CI)                          |               |               |               |                |                |
| Adjusted RRR (CI)                 |               |               |               |                |                |
| MI only                           | 321,285 (86.7) | 38,273 (10.3) | 8,404 (2.3)   | 2,548 (0.7)   | 49,225 (13.3)  |
| n (%)                             |               |               |               |                |                |
| ST only                           | 80,799 (72.0)  | 22,104 (19.7) | 5,238 (4.7)   | 4,149 (3.7)   | 31,491 (28.0)  |
| RRR (CI)                          |               |               |               |                |                |
| Adjusted RRR (CI)                 |               |               |               |                |                |
| Cardiometabolic multimorbidity    | 205,493 (72.6) | 64,146 (22.7) | 9,072 (3.2)   | 4,342 (1.5)   | 77,561 (27.4)  |
| n (%)                             |               |               |               |                |                |
| RRR (CI)                          |               |               |               |                |                |
| Adjusted RRR (CI)                 |               |               |               |                |                |

All Relative Risk Ratios (or multinomial odds ratios) were calculated relative to those with no cardiometabolic condition and no activity limitation. The following variables were controlled in the adjusted RRR’s: age, sex, level of education, total household income, marital status, retirement status, rural/urban location, ethnicity, and the MOS scale of functional social support; DM = diabetes mellitus; MI = myocardial infarction; ST = stroke
### Activity Limitation Classification

|                  | CM – 2 Disease | DM + MI | DM + Stroke | MI + Stroke | CM – 3 Disease / DM + MI + Stroke |
|------------------|----------------|---------|-------------|-------------|-----------------------------------|
| **n (%)**        | 197,125 (73.8) | 149,297 (77.3) | 32,640 (68.3) | 15,187 (58.5) | 8,368 (52.1)                     |
| **RRR (CI)**     | 4.165 (3.57–4.861) | 3.511 (2.918–4.225) | 6.147 (4.386–8.615) | 7.422 (4.658–11.827) | 11.310 (6.897–18.545)            |
| **Adjusted RRR (CI)** | 3.459 (2.844–4.207) | 2.831 (2.242–3.576) | 5.655 (3.678–8.694) | 5.802 (3.242–10.386) | 9.930 (4.935–19.980)             |

All Relative Risk Ratios (or multinomial odds ratios) were calculated relative to those with no cardiometabolic condition and no activity limitation. The following variables were controlled in the adjusted RRR's: age, sex, level of education, total household income, marital status, retirement status, rural/urban location, ethnicity, and the MOS scale of functional social support; DM = diabetes mellitus; MI = myocardial infarction; ST = stroke.

Participants with two cardiometabolic conditions had a greater odds of reporting mild, moderate, and severe/total activity limitation compared to those with no cardiometabolic condition (Fig. 2). The multinomial odds ratio (i.e., relative risk ratio) increased in all activity limitation categories with increasing number of conditions, ranging from 1.9 to 9.9 in the mild activity limitation category to 3.5 to 14.0 in the severe/total activity limitation category. Of the two disease CM combinations, those that included stroke (DM + Stroke and MI + Stroke) showed an increased odds of developing any (6.546 and 5.803, respectively), mild (5.655 and 5.802, respectively), moderate (14.550 and 14.098, respectively), and severe/total (8.115 and 13.085, respectively) activity limitations.
Participants with all three cardiometabolic conditions had the highest odds of reporting activity limitations relative to other diagnostic groups.

Discussion

Existing research on multimorbidity has defined the condition quite broadly and focussed primarily on mortality rates. However, patients living with multimorbidity can still live with various severities of activity limitation prior to death and different patterns of multimorbidity will result in different severity of activity limitations. Our analysis was conducted to determine the prevalence and severity of activity limitation among Canadians with cardiometabolic conditions, and to examine the association between activity limitation with increasing numbers of cardiometabolic conditions. Our findings of increasing activity limitation with increasing onset of cardiometabolic conditions, highlights the importance of both primary and secondary prevention of cardiometabolic diseases in the Canadian adult population.

Our results indicate that people with stroke have the greatest odds of reporting activity limitation relative to people with diabetes or myocardial infarction only. A similar result was observed by Xu, et al., who demonstrated that the rate of progression to CM was highest in people that first suffered a stroke. This finding is consistent with the pathophysiology of stroke, when acute brain damage at the time of the event may result in various neurological impairments (e.g. motor dysfunction, speech and language impairment, etc.) and ultimately impact activities of daily living. For example, 80% of stroke survivors have long-term motor impairment, >50% have sensory impairments, and 20% of all stroke survivors have ongoing communication issues due to aphasia. Issues with mood after stroke are also common with as many as 36% reporting depressive symptoms, 23% reporting anxiety, and 25% experiencing psychological stress. These motor and cognitive impairments may impact a patient's ability to engage in prevention activities (e.g., daily exercise, healthy meal preparation), resulting in the acceleration of other underlying disease process, such as diabetes and myocardial infarction. Conversely, myocardial infarction and diabetes typically spare neurological function and result in less direct activity impairment and a more gradual progression of morbidity.

The multiplicative effect of activity limitation with onset of additional cardiometabolic conditions seen in our analysis is also observed in similar studies examining the associations between CM and other health outcomes. For two disease combinations, the observed odds of activity limitation were greatest at all severities when one of the two diseases included stroke. Similar results are reported in other studies. For example, Hoeymans et al. reported that each of stroke and diabetes were found to have the greatest odds of activity limitation relative to other chronic conditions, including heart disease. Similarly, Hung et al. reported that stroke, congestive heart failure, and diabetes were all associated with mobility and complex task activity limitation, and Liang et al. observed that all CM health conditions were associated with an increased likelihood of ADL activity limitation.

Our findings combined with previous evidence suggest an increasing importance of secondary prevention efforts after an initial diagnosis of a cardiometabolic condition. Prevention of CM will lead to fewer activity limitations, and improved independence and quality of life.

Study Limitations

Limitations of our study include the self-reported nature of disease status. For example, the question relating to diabetes asked the participants if a doctor had ever told them that they had high blood sugar. This may have resulted in an overestimation of the prevalence of diabetes as it could have included some participants with pre-diabetes. Additionally, the CLSA survey is limited in that it excluded residents from the three territories, persons living on federal First Nations reserves, full-time members of the Canadian Armed Forces, and individuals living in institutions. This may have contributed to an underestimation of CM in the Canadian population. Furthermore, the cross-sectional nature of our data limits conclusions that may be made between activity limitations and cardiometabolic conditions.

Conclusion

Activity limitations increase with increasing onset of cardiometabolic conditions and this is most obvious in those who are living with the effects of stroke. Our findings indicate the importance of prevention in patients living with one or more cardiometabolic
conditions. Preventative and/or treatment regimens that target stroke are of particular importance as the occurrence of stroke greatly increases an individual’s risk of activity limitation. This is of particular importance in patients that have diabetes, have suffered a myocardial infarction, or both, as the occurrence of a stroke substantially increases the individual’s risk of activity limitation. Although our analyses demonstrate a clear association between CM and activity limitation, further investigation is required to better understand the causal nature between CM and activity limitation.

Abbreviations

ADL – Activities of Daily Living
CI – Confidence Interval
CLSA – Canadian Longitudinal Study on Aging
CM – Cardiometabolic multimorbidity
DM – Diabetes Mellitus
iADL – Instrumental Activities of Daily Living
MI – Myocardial Infarction
OARS – Older American Resources and Services (OARS)
RRR – Relative Risk Ratio

Declarations

Ethics approval and consent to participate:
We used data from the Canadian Longitudinal Study of Aging (CLSA) in this study. Individuals consented to participate in the CLSA. For this secondary analysis of data we obtained ethics approval from the University of British Columbia’s Behavioural Research Ethics Board (H19-00485)

Consent for publication:
Not applicable.

Availability of data and materials:
The data that support the findings of this study are available from the Canadian Longitudinal Study on Aging, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission from the Canadian Longitudinal Study on Aging.

Competing interests:
The authors declare that they have no competing interests.

Funding:
Michael Smith Foundation for Health Research Scholar Award (BMS)

Authors’ contributions:
BF: Conceptualization, Methodology, Software, Investigation, Writing – Original Draft, Visualization JS: Formal Analysis, Methodology, Validation, Writing – Review & Editing TK: Writing – Review & Editing BMS: Conceptualization, Methodology, Data Curation, Writing – Review & Editing, Supervision, Project Administration, Funding Acquisition
Acknowledgments:

This research was made possible using the data collected by the Canadian Longitudinal Study on Aging (CLSA). Specific data used included the CLSA Baseline Tracking Dataset version 3.4 and Comprehensive Dataset version 4.0, under Application Number 180906. Funding for the Canadian Longitudinal Study on Aging (CLSA) is provided by the Government of Canada through the Canadian Institutes of Health Research (CIHR) under grant reference: LSA 94473 and the Canada Foundation for Innovation. The CLSA is led by Drs. Parminder Raina, Christina Wolfson and Susan Kirkland. The funding agencies had no role in writing the manuscript, study design, data collection, analyses, or interpretation of results.

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