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# Prediabetes Progression to Diabetes among Veterans with Post Traumatic Stress Disorder

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## Abstract

Prevalence of diabetes and prediabetes, post-traumatic stress disorder (PTSD) as well as atherosclerotic cardiovascular disease is very high among veterans. The primary aim of this study is to compare the rate of progression of prediabetes to diabetes among veterans with or without PTSD and associated conditions and or risk factors for that. This retrospective observational database study included all subjects with prediabetes based on HbA1C (5.7 to 6.4), after exclusion criteria between 2008 and 2019 at Veterans Health Administration at Columbia, South Carolina. PTSD codes were used to identify veterans with PTSD. Subjects with prediabetes identified include 72,604 with mean age of 66 and mean HbA1C of 5.9% and 29% of them had PTSD. Follow-up data is available for 62,184 subjects. Among those who had follow-up, 35% progressed to diabetes, while 65% remained as prediabetic. Progression to diabetes negatively is correlated with HbA1C (r = 0.34; $p < 0.001$). Associated other risks include obesity, hypertension and atherosclerotic cardiovascular disease. The rate of progression was higher among subjects with PTSD though much younger than those without PTSD.

## Keywords

Diabetes, Prediabetes, Progression to Diabetes, Hemoglobin A1C, Post-Traumatic Stress Disorder

## 1. Background

Posttraumatic stress disorder (PTSD), traumatic exposure frequently involving actual or threatened physical harm with very high prevalence rates of 12% - 30% among combat veterans compared to life time risk of 7.8% in general population in the United States [1]. Prediabetes (PDM) is an intermediate condition with hemoglobin A1C (HbA1C) between 5.7 and 6.4, and at a higher risk of developing type 2 diabetes. Both obesity and PTSD are common among veterans. Veterans with PTSD are at higher risk for obesity [2]. In general, post-deployment period is said to be critical for weight gain, more so among all veterans with PTSD. Among veterans with PTSD, women veterans had a higher rate than men [3]. In an observational study, reductions in PTSD scores were reported to be associated with a lower risk of incident type 2 diabetes (T2DM) [4]. This incident diabetes among veterans with PTSD is said to be 3.5 times higher compared to those without obesity and that signifies the role of obesity for incident T2DM [5]. Obesity and overweight are high among veterans with obesity rates of 41% and overweight of 37%. PTSD is associated with increased prevalence of DM [5] [6] and cardiovascular disease [7] [8] [9] [10] [11]. Prevalence of diabetes and prediabetes, PTSD as well as cardiovascular disease are very high among veterans. Prevalence of type 2 diabetes among veterans is >25%. In the USA, 33.9% population (84.1 million adults) have prediabetes. The primary objectives of this study are to compare the rate of progression of prediabetes to diabetes among veterans with or without PTSD and identify associated conditions and or risk factors for that.

## 2. Methods

Design: Single center, retrospective study with subjects with prediabetes (hemoglobin A1C between 5.7 and 6.4 at William Jennings Bryan Dorn Veteran Hospital in Columbia SC. All available subjects have prediabetes from 2008 January to June 2019 with no exclusion criteria. The data of prediabetes is analyzed between subjects with prediabetes and PTSD compared to that of prediabetes without PTSD. The data for this study was collected from computerized patient record system (CPRS) based on hemoglobin A1C who qualifies for Prediabetes and without a diagnosis of diabetes or diabetes therapeutic medications; Codes for PTSD used for presence or absence of PTSD, after approval by institutional review board (IRB) as well as research and development board.

## 3. Statistical Analysis

Data collected is expressed as means and standard deviation of the mean. The rate of progression to diabetes by each year and their relation to baseline HbA1C was carried out. The associated risk factors in those progressed to diabetes are compared between those with or without PTSD. Correlation between the rate of progression with baseline HbA1C carried out.

## 4. Results

Among 72,604 subjects with PDM, 20,963 had PTSD while 51,641 subjects did not have the diagnosis of PTSD. The comparative data of subjects with or without PTSD is shown in **Table 1**. Among all the subjects with PDM, 62,140 had follow up HbA1C and/or other labs. Follow up data includes follow up of 2 - 9 years. Among those who had follow up, 21,986 (35%) progressed to diabetes, while 40,154 (65%) remained as prediabetic. Progression to diabetes negatively

Table 1. Comparison of data between those who have PTSD and those without PTSD in prediabetic veterans at baseline.

| | All Subjects | PDM + PTSD | PDM with no PTSD |
|---|---|---|---|
| **Total number** | 72,604 | 20,963 | 51,641 |
| **Age** | 66 ± 14 | 67 ± 15 | 69 ± 12 |
| **BMI** | 32 ± 2.6 | 33 ± 6 | 31 ± 2.8 |
| **HbA1C** | 5.9 ± 1.1 | 5.9 ± 1.2 | 5.9 ± 1.1 |
| **HTN (%)** | 55 | 56 | 57 |
| **ASCVD (%)** | 13 | 13 | 14 |
| **Hyperlipidemia/meds (%)** | 55 | 50 | 58 |

PTSD: post-traumatic stress disorder HTN: hypertension; ASCVD: atherosclerotic cardiovascular disease; PDM: prediabetes; BMI: body mass index.

correlated with HbA1C (r = 0.34; $p < 0.001$). The comparative data of those progressed and who did not progress is shown in Table 2. The mean age of subjects with PTSD who progressed to diabetes is 65 compared to those without PTSD is 69. The comparative data of associated risk factors include obesity, hypertension and atherosclerotic cardiovascular disease among those progressed to T2Dm between those with or without PTSD are shown in Table 3. As noted in Table 3, though the subjects with PTSD are much younger and less number of associated risk factors have progressed to diabetes. The rate of progression to diabetes over time and associated increased percentage of associated risk factors such as age, hypertension, ASCVD and baseline HbA1C are shown in Table 4.

## 5. Discussion

Both obesity and PTSD are common among veterans. Veterans with PTSD are at higher risk for obesity [2]. The findings of the current study suggest that subjects with PTSD have higher BMI compared to those without PTSD as shown in Table 1. The post-deployment period is critical for weight gain, particularly for veterans diagnosed with PTSD, more so among women veterans with PTSD [3]. Obesity is a high-risk factor for insulin resistance. Obesity and overweight are very high among veterans with obesity rates of 41% and overweight of 37%. In this study, most of the prediabetics are obese. Lifestyle modification and weight loss interventions have been successful in preventing or delaying progression from PDM to T2DM in the Diabetes Prevention Program (DPP) [12] and Finnish DPP [13].

There is a significant difference in the rate of progression to T2DM between those with or without PTSD ($p$ = 2.760E−16) as well as age ($p$ = 1.7E−215) and prevalence of atherosclerotic cardiovascular disease ($p$ = 8.53E−22). Interestingly, the rate of progression to diabetes negatively correlates with the baseline HbA1C in subjects with PTSD (t = 0.338; $p < 0.01$). PTSD is associated with increased prevalence of metabolic syndrome (21.3% vs controls 2.5%; $p < 0.001$)

Table 2. Comparison of % progressed to diabetes, with or without PTSD.

| | Total | Pro to DM | % Pro | No Prog | % No Pro |
|---|---|---|---|---|---|
| **PDM with F/U** | 62,140 | 21,986 | 35 | 40,154 | 65 |
| **PDM + PTSD** | 20,963 | 7017 | 33.5 | 13,974 | 66.6 |
| **PDM with No PTSD** | 41,177 | 14,969 | 36.4 | 26,208 | 63.6 |

F/U: follow up; %Pro: % progressed to diabetes; No Pro: not progressed to diabetes; PTSD: post-traumatic stress disorder; PDM: prediabetes.

Table 3. Comparison of parameters between prediabetes subjects progressed to Diabetes with or without PTSD.

| | PDM + No PTSD | PDM + PTSD | *p*-Value |
|---|---|---|---|
| **No.** | 14969 | 7017 | <0.01 |
| **Age** | 69 | 65 | <0.01 |
| **HTN %** | 79 | 54 | <0.01 |
| **CAD%** | 21 | 10 | <0.01 |
| **HbA1C** | 6.15 | 5.9 | <0.01 |

HTN; hypertension; CAD: atherosclerotic heart disease; PDM: prediabetes; PTSD: post-traumatic stress disorder.

Table 4. Rate of progression of prediabetes to diabetes each year from baseline.

| | % Sub | Mean A1C | Mean age | HTN (%) | ASCAD (%) |
|---|---|---|---|---|---|
| **<1Y** | 35 | 6.23 | 70.3 | 81 | 22 |
| **1 - 2Y** | 25 | 6.17 | 69.4 | 78 | 18 |
| **2 - 3Y** | 13 | 6.12 | 69.2 | 78 | 16 |
| **3 - 4Y** | 9 | 6.1 | 68.4 | 71 | 13 |
| **4 - 5Y** | 6 | 6.07 | 68.7 | 70 | 13 |
| **>5Y** | 12 | 6.02 | 67.5 | 73 | 12 |

% sub: percentage of subjects progressed to diabetes; HTN: hypertension; ASCVD: atherosclerotic cardiovascular disease.

and insulin resistance as calculated by HOMA-IR (4.3 ± 4.3 vs controls 2.4 ± 2.0; $p < 0.001$) compared to controls [14]. In addition, inactivity can contribute for the rate of progression to diabetes as reported in a study of physical activity and physical performance among psychiatric disorders, Hall KS *et al.* reported negative association between PTSD and physical function in older military veterans [15]. These may be the reasons why the prevalence of DM is high among subjects with PTSD. PTSD is said to be associated with increased prevalence of DM [5] [6] and cardiovascular disease [7] [8] [9] [10] [11]. Combined islet dysfunction comprised of impaired insulin secretion and exaggerated glucagon secretion is the key defect of hyperglycemia. In general, annual incidence rates for progression to T2DM were 7.6% [16], similar to our data that suggest 6% - 6.5% annual progression. Importance of diet, lifestyle interventions and increased physical activity are said to decrease progression of PDM to diabetes [17] [18]. PTSD and associated cardiometabolic disease and its sequelae lead to diminished quality of life, and also contribute substantially to the PTSD-associated excess mortality rate, which is 2 - 3 times higher than the general population [19] [20] [21] [22].

Our data shows that prevalence of hypertension and ASCVD is high among subjects with no PTSD compared to those without PTSD. But the rate of progression is faster in association with higher rates of hypertension and ASCVD presence as shown in **Table 4**. That indicates those with higher rates of metabolic syndrome are at higher risk for progression to diabetes.

C-reactive protein (CRP), a marker of systemic inflammation, has been associated with psychiatric disorders including major depressive disorder (MDD) and PTSD. Prediabetes is associated with adverse cardiovascular risk, in addition to be high risk of progression to diabetes. Framingham heart study indicated noted that subjects with prediabetes who never progress to diabetes also confer increased propensity for death from a cardiovascular cause.

Natural history of diabetes starts with genetic predisposition with normal glucose tolerance followed by insulin resistance with weight gain, then prediabetes and then progression to T2DM with superimposed beta cell failure. Thus, PDM is a high-risk state for future development of T2DM. As PDM progresses to T2DM glucolipotoxicity occurs. This glucolipotoxicity with metabolic derangement is secondary to impaired $\beta$-Cell function leading to increase in fasting and/or increase in post prandial glucose, release of fatty acids from adipose tissue [23]. PTSD is associated with increased risk of type 2 diabetes (T2DM) [24] [25]. Prevalence of diabetes and prediabetes, PTSD as well as cardiovascular disease are very high among veterans. prevalence of type 2 diabetes among veterans is >25%. In the USA, 33.9% population (84.1 million adults) have prediabetes and most of them are >65 years old.

## 6. Conclusion

Early identification of high-risk pre-diabetic patients is a critical step in the treatment and prevention of DM and associated atherosclerotic cardiac disease. In subjects with PTSD, control of PTSD, increase in activity and preventing weight gain and initiation of weight loss measures are important to prevent progression to diabetes and or regression to normoglycemia.

## Limitations

Since it is a retrospective study, two-hour post prandial glucoses are not available. Second limitation is limited information on family history of diabetes and socioeconomic status. Third is lack of lifestyle information. Fourth is the activity of PTSD.

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## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

## References


[1] Shahmiri Barzoki, H., *et al.* (2021) Studying the Prevalence of PTSD in Veterans, Combatants and Freed Soldiers of Iran-Iraq War: A Systematic and Meta-Analysis Review. *Psychology*, *Health & Medicine*, 1-7. https://doi.org/10.1080/13548506.2021.1981408

[2] Dorflinger, L.M. and Masheb, R.M. (2018) PTSD Is Associated with Emotional Eating among Veterans Seeking Treatment for Overweight/Obesity. *Eating Behaviors*, **31**, 8-11. https://doi.org/10.1016/j.eatbeh.2018.07.005

[3] Buta, E., *et al.* (2018) Posttraumatic Stress Disorder Diagnosis and Gender Are Associated with Accelerated Weight Gain Trajectories in Veterans during the Post-Deployment Period. *Eating Behaviors*, **29**, 8-13. https://doi.org/10.1016/j.eatbeh.2018.01.002

[4] Scherrer, J.F., *et al.* (2019) Association between Clinically Meaningful Posttraumatic Stress Disorder Improvement and Risk of Type 2 Diabetes. *JAMA Psychiatry*, **76**, 1159-1166. https://doi.org/10.1001/jamapsychiatry.2019.2096

[5] Scherrer, J.F., *et al.* (2018) The Role of Obesity in the Association between Posttraumatic Stress Disorder and Incident Diabetes. *JAMA Psychiatry*, **75**, 1189-1198. https://doi.org/10.1001/jamapsychiatry.2018.2028

[6] Hoerster, K.D., *et al.* (2019) PTSD Is Associated with Poor Health Behavior and Greater Body Mass Index through Depression, Increasing Cardiovascular Disease and Diabetes Risk among U.S. Veterans. *Preventive Medicine Reports*, **15**, Article ID: 100930. https://doi.org/10.1016/j.pmedr.2019.100930

[7] Beristianos, M.H., *et al.* (2016) PTSD and Risk of Incident Cardiovascular Disease in Aging Veterans. *The American Journal of Geriatric Psychiatry*, **24**, 192-200. https://doi.org/10.1016/j.jagp.2014.12.003

[8] Cohen, B.E., Edmondson, D. and Kronish, I.M. (2015) State of the Art Review: Depression, Stress, Anxiety, and Cardiovascular Disease. *American Journal of Hypertension*, **28**, 1295-1302. https://doi.org/10.1093/ajh/hpv047

[9] Dyball, D., Evans, S., Boos, C.J., Stevelink, S.A.M. and Fear, N.T. (2019) The Association between PTSD and Cardiovascular Disease and Its Risk Factors in Male Veterans of the Iraq/Afghanistan Conflicts: A Systematic Review. *International Review of Psychiatry*, **31**, 34-48. https://doi.org/10.1080/09540261.2019.1580686

[10] Edmondson, D. and Cohen, B.E. (2013) Posttraumatic Stress Disorder and Cardiovascular Disease. *Progress in Cardiovascular Diseases*, **55**, 548-556. https://doi.org/10.1016/j.pcad.2013.03.004

[11] Edmondson, D. and von Kanel, R. (2017) Post-Traumatic Stress Disorder and Cardiovascular Disease. *The Lancet Psychiatry*, **4**, 320-329. https://doi.org/10.1016/S2215-0366(16)30377-7

[12] Knowler, W.C., *et al.* (2002) Reduction in the Incidence of Type 2 Diabetes with

Lifestyle Intervention or Metformin. *The New England Journal of Medicine*, **346**, 393-403. https://doi.org/10.1056/NEJMoa012512

[13] Lindstrom, J., *et al.* (2006) Sustained Reduction in the Incidence of Type 2 Diabetes by Lifestyle Intervention: Follow-Up of the Finnish Diabetes Prevention Study. *The Lancet*, **368**, 1673-1679. https://doi.org/10.1016/S0140-6736(06)69701-8

[14] Blessing, E.M., *et al.* (2017) Biological Predictors of Insulin Resistance Associated with Posttraumatic Stress Disorder in Young Military Veterans. *Psychoneuroendocrinology*, **82**, 91-97. https://doi.org/10.1016/j.psyneuen.2017.04.016

[15] Hall, K.S., *et al.* (2014) PTSD Is Negatively Associated with Physical Performance and Physical Function in Older Overweight Military Veterans. *Journal of Rehabilitation Research & Development*, **51**, 285-295. https://doi.org/10.1682/JRRD.2013.04.0091

[16] DeFronzo, R.A., *et al.* (2011) Pioglitazone for Diabetes Prevention in Impaired Glucose Tolerance. *The New England Journal of Medicine*, **364**, 1104-1115. https://doi.org/10.1056/NEJMoa1010949

[17] Jadhav, R.A., *et al.* (2017) Effect of Physical Activity Intervention in Prediabetes: A Systematic Review with Meta-Analysis. *Journal of Physical Activity and Health*, **14**, 745-755. https://doi.org/10.1123/jpah.2016-0632

[18] Wu, T., *et al.* (2009) Long-Term Effectiveness of Diet-plus-Exercise Interventions vs. Diet-Only Interventions for Weight Loss: A Meta-Analysis. *Obesity Reviews*, **10**, 313-323. https://doi.org/10.1111/j.1467-789X.2008.00547.x

[19] Ahmadi, N., *et al.* (2018) The Long-Term Clinical Outcome of Posttraumatic Stress Disorder with Impaired Coronary Distensibility. *Psychosomatic Medicine*, **80**, 294-300. https://doi.org/10.1097/PSY.0000000000000565

[20] Ahmadi, N., *et al.* (2011) Post-Traumatic Stress Disorder, Coronary Atherosclerosis, and Mortality. *American Journal of Cardiology*, **108**, 29-33. https://doi.org/10.1016/j.amjcard.2011.02.340

[21] Zatzick, D.F., *et al.* (1997) Posttraumatic Stress Disorder and Functioning and Quality of Life Outcomes in a Nationally Representative Sample of Male Vietnam Veterans. *The American Journal of Psychiatry*, **154**, 1690-1695. https://doi.org/10.1176/ajp.154.12.1690

[22] Powers, A., *et al.* (2019) The Differential Effects of PTSD, MDD, and Dissociation on CRP in Trauma-Exposed Women. *Comprehensive Psychiatry*, **93**, 33-40. https://doi.org/10.1016/j.comppsych.2019.06.007

[23] Poitout, V. and Robertson, R.P. (2008) Glucolipotoxicity: Fuel Excess and Beta-Cell Dysfunction. *Endocrine Reviews*, **29**, 351-366. https://doi.org/10.1210/er.2007-0023

[24] Vancampfort, D., *et al.* (2016) Physical Activity in People with Posttraumatic Stress Disorder: A Systematic Review of Correlates. *Journal of Physical Activity and Health*, **13**, 910-918. https://doi.org/10.1123/jpah.2015-0436

[25] Roberts, A.L., *et al.* (2015) Posttraumatic Stress Disorder and Incidence of Type 2 Diabetes Mellitus in a Sample of Women: A 22-Year Longitudinal Study. *JAMA Psychiatry*, **72**, 203-210. https://doi.org/10.1001/jamapsychiatry.2014.2632