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The descriptive epidemiology of daily sitting time as a sedentary behaviour in multiple sclerosis

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Abstract

Background: Sedentary behavior is pervasive among the general population, but little is known about the epidemiology of this behavior in multiple sclerosis (MS).

Objective: We compared self-reported sitting time (ST), as a measure of sedentary behavior, between persons with MS and healthy controls, and examined ST across demographic and clinical characteristics of those with MS.

Methods: 1081 persons with MS and 150 healthy controls self-reported ST based on the International Physical Activity Questionnaire (IPAQ), and completed the Godin Leisure-Time Exercise Questionnaire (GLTEQ) and a demographic/clinical scale. Data were analyzed using analysis of variance, bivariate correlations, and stepwise regression analysis.

Results: There was not a significant difference in ST between persons with MS and controls ($F=0.01$, $p=0.95$), and persons with MS reported 450.9 ± 220.6 minutes of ST per day. ST was weakly associated with GLTEQ scores in MS ($r=-.21$, $p<.001$), but not controls. ST significantly differed as functions of marital status, physical activity level, employment status, education, and degree of ambulatory impairment among those with MS.

Conclusions: ST does not differ between persons with MS and healthy controls, but those with MS report a large amount of this sedentary behavior that is potentially an independent correlate of health and disease outcomes.

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Keywords

Multiple sclerosis; sedentary behavior; sitting; health behavior; physical inactivity

INTRODUCTION

Sedentary behavior (i.e., behavior involving sitting or lying that does not increase energy expenditure during the waking hours) is pervasive among adults in Western countries¹ and world-wide². Adults in countries around the world accumulate between 3 and 8 hours of sitting time (ST) per day². ST has been detrimentally associated with disease risk factors such as blood glucose and obesity³, as well as increased risks of morbidity and mortality^{2,4} independent of physical activity. Accordingly, researchers have begun focusing on sedentary behavior, particularly reducing or breaking-up daily ST, as an important target of behavioral interventions for reducing health risks^{5,6}.

To date, the majority of research on sedentary behavior has focused on the general population without a chronic disease condition, and there is minimal research on sedentary behavior in adults with progressive diseases that result in mobility disability⁷ such as multiple sclerosis (MS). MS is a common immune-mediated disease of the central nervous system (CNS) that causes axonal demyelination, transection, and loss as well as neurodegeneration over time. Such damage of the CNS tissue results in the clinical expressions of MS that progressively result in the accumulation of ambulatory impairment⁸. The clinical expression of MS and associated ambulatory impairment might increase the rate of sedentary behavior in persons with MS. One small study has quantified sedentary time as an estimated 8 hours per day in persons with MS⁹. This study indicates that sedentary time differs based on disability status, but did not examine other variables for a good description of demographic and clinical variables that might explain differences in ST. There further was not comparison with controls.

The present study involved a secondary, exploratory analysis of existing data and compared self-reported ST between persons with MS and controls without MS or any other disease conditions. We secondly examined self-reported ST among demographic and clinical characteristics of persons with MS. This paper provides additional information regarding the possible public health crisis involving ST in persons with MS, and potentially identifies a new avenue for behavioral interventions for improving health and possibly disease status in this population, if there is a high rate of sedentary behavior.

METHOD

Participants

The current study involved a secondary analysis of data amalgamated from 13 previous investigations^{10–22} of physical activity and its associations with quality of life, social cognitive and symptomatic outcomes; all data from those investigations had been previously de-identified. Studies were included in the data amalgamation that included an assessment of clinical characteristics (i.e. disability status and disease duration), sociodemographic

variables (i.e. sex, age, BMI, education, etc.), and ST (questions 7 of the International Physical Activity Questionnaire (IPAQ)). There were 13 studies that contained those data and the de-identified data were compiled across those studies into a single data set for analyses. MS participant recruitment occurred throughout the United States, but primarily within the Midwest and the state of Illinois. Potential participants were contacted through print and email flyers and advertisement on the National Multiple Sclerosis Society website. Healthy controls were recruited through the University community via public email postings. Persons with MS were recruited based on the following common inclusion criteria: (1) diagnosis of MS; (2) relapsefree in the previous 30 days; and (3) ambulatory with or without assistance. The final combined samples of convenience included 1081 persons with MS and 150 healthy controls.

Self-report ST and physical activity measures

ST was measured using item seven from the abbreviated version of the IPAQ²³, and scores from this item have been validated with accelerometry²⁴. This item reads, “During the last 7 days, how much time did you spend sitting on a weekday?” The item further has instructions regarding the location and opportunity for ST such as at work or home and while doing course work or during leisure time. The item includes examples of sitting activities such as sitting at a desk, visiting friends, reading, or watching television. Participants indicated their ST by writing in the number of hours in a single blank below the instructions.

Physical activity was measured with the Godin Leisure-Time Exercise Questionnaire (GLTEQ)²⁵. The GLTEQ measures the frequency of strenuous, moderate, and mild leisure time physical activity performed for periods of 15 minutes or more over a usual week. The overall GLTEQ score was calculated by multiplying the frequencies of strenuous, moderate, and mild by 9, 5, and 3 METs, respectively, and yielded a continuous measure of leisure physical activity in arbitrary units²⁶.

Disability status

The Patient Determined Disease Steps (PDDS)^{27,28} scale is a single-item, self-reported measure of disability status. The PDDS ranges from 0 (Normal) to 8 (Bedridden), and has been recommended as a surrogate for the physician-rated Expanded Disability Status Scale (EDSS)²⁸ when neurological examination is not suitable (e.g., survey-based research). Scores from the PDDS have been strongly and linearly associated with EDSS scores ($r=.783$)²⁸. PDDS scores were trichotomized into groups of ambulatory disability. Scores of 0-2 were categorized as “no ambulatory impairment,” scores of 3-4 were categorized as “mild ambulatory impairment” and scores above 5 were categorized as “moderate-severe ambulatory impairment.” Similar classifications have been reported previously^{29,30}.

Sociodemographic and clinical variables

Sociodemographic and clinical characteristics were measured with a standard scale. Sex, age, body mass index (BMI), marital status, number of children, employment status, race, education, and income were included as sociodemographic variables. The following sociodemographic variables were collapsed into groups for ease of analysis: age (18-39 vs. 40-59 vs. >60), BMI (normal vs. overweight vs. obese), marital status (married vs.

unmarried), children (no children vs. children), race (Caucasian vs. non-Caucasian), education (college graduate vs. non-college graduate), and income (< \$40,000/year vs. > \$40,000/year). Clinical course of MS was determined by standard definitions³¹ and disease duration was identified as the time since the date of confirmed MS diagnosis. The following clinical variables were collapsed into groups as a justifiable means to segment the data for clinically relevant groups: disease type (Relapsing Remitting MS vs. Progressive MS), PDDS (no impairment, mild ambulatory impairment and moderate-severe ambulatory impairment), and disease duration (<10 years, 10-20 years, and >20 years).

Procedure

All studies were approved by the same University Institutional Review Board, and all data were de-identified before amalgamation. All participants provided written informed consent. Participants were either sent a battery of questionnaires through the United States Postal Service (USPS) with a stamped, pre-addressed return envelope or completed questionnaires during a baseline testing session in the laboratory. If the questionnaires were received via USPS, the researchers verified the questionnaires were complete upon return. Any participant with missing information was collected over the phone. If the questionnaires were completed during a baseline testing session, the questionnaires were checked for completion prior to the participant completing the session and any missing information was obtained. All participants received compensation for successful completion of the questionnaires.

Data analysis

All data analyses were conducted on de-identified data in IBM SPSS Statistics Version 21 for Windows (SPSS, Inc., Chicago, IL). Descriptive statistics are provided in text and tables as mean (*M*) with standard deviation (*SD*) unless otherwise noted (e.g., medians or percentages). We initially compared the MS and control groups for differences in demographic and physical activity variables using independent samples *t*-test and/or chi-square tests. The primary analytic model for examining sitting behavior involved a between-subjects analysis of variance (ANOVA) on self-reported ST per day from question seven of the IPAQ. The between-subjects factors were based on group (i.e., MS vs. healthy control), or sociodemographic (i.e., sex, age, BMI, marital status, number of children, employment, race, education, and income) and clinical (i.e., MS type, disease duration, and ambulatory status based on PDDS score) factors in those with MS separately. Bonferroni follow-up analyses were performed to identify significant differences in ST for significant between-subjects effects involving 3 or more groups in the ANOVAs. Effect size estimates based on Cohen's *d* (i.e., difference between mean scores for two groups divided by the pooled standard deviation) are provided and delineated as small, medium, and large based on the criteria of 0.2, 0.5, and 0.8, respectively³². We further examined the association between ST and physical activity (i.e., GLTEQ scores) using a Pearson product-moment correlation in persons with MS and controls separately. We performed multiple linear regression analyses with stepwise entry to examine the independent contributions of variables associated ST in only the MS sample.

RESULTS

Sociodemographic and clinical characteristics of samples

Table 1 provides the sociodemographic characteristics and identified differences between the samples of participants with MS and healthy controls, and the clinical characteristics of the participants with MS. The mean PDDS score for the MS participants was 2.0 (range=0–8), indicating that the sample was characterized by moderate disability (i.e. no restrictions in walking but significant limitations to daily activity due to MS). The disability ranged between normal and bilateral assistance (e.g. rollator or frame). The mean duration of MS was 9.7 years with 90% ($n=973$) of the sample reporting a diagnosis of relapsing remitting multiple sclerosis (RRMS). There were no differences between MS and controls for marital status, number of children, and income, but there were differences in sex, age, BMI, employment, race, and education ($p<0.05$).

ST and physical activity in MS versus controls

The ST for persons with MS versus controls are presented in Figure 1. The ANOVA did not identify a significant difference in minutes of ST between MS and controls ($F=0.01$, $p=0.95$). The mean scores for ST ($M\pm SD$) were 449.6 ± 169.6 and 450.9 ± 220.6 minutes per day for control and MS participants, respectively. This was unchanged after controlling for sociodemographic variables that differed between groups in ANCOVA ($F=0.49$, $p=0.49$). The ANOVA identified significant differences between groups in physical activity based on GLTEQ scores ($F=81.258$, $p<0.001$). The mean scores were 23.9 ± 23.1 and 41.6 ± 26.7 for MS and controls, respectively. The difference of 17.7 was moderate in magnitude based on Cohen's d of 0.7. ST was significantly and weakly associated with GLTEQ scores in those with MS ($r=-0.21$, $p<0.001$), but not in the control sample ($r=0.01$, $p=0.90$).

ST per sociodemographic characteristics with MS

Figure 1 displays ST per sociodemographic characteristics in persons with MS. The ANOVA identified statistically significant differences in ST when considering BMI ($F=4.793$, $p=0.009$), marital status ($F=20.272$, $p<0.001$), children ($F=7.00$, $p=0.008$), and employment status ($F=6.99$, $p=0.01$). When considering BMI, a Bonferroni follow up analysis indicated significant differences between normal and obese participants ($p=0.011$) and overweight and obese participants ($p=0.039$). Obese participants spent 49 and 53 more minutes per day sitting than normal ($d=0.3$) and overweight ($d=0.2$) participants, respectively. The analysis of marital status revealed a difference of 64.2 minutes of sitting per day ($d=0.3$) with unmarried persons sitting more than married persons with MS. When comparing children, persons without offspring sat for 38.5 more minutes of sitting per day ($d=0.2$) between those persons with children. The analysis of employment status indicated a difference of 36.8 minutes per week of sitting that was small in magnitude ($d=0.2$) between those who were employed, who sat more, versus unemployed. Sex, age, race, education, and income were not significantly associated with time sitting in the ANOVA ($p>0.05$). We further confirmed the lack of associations between ST and age ($r=0.040$, $p=0.188$), and income ($r=-0.037$, $p=0.230$) using bivariate correlations with those variables on non-categorical units (e.g. age in actual years rather than groups). The bivariate correlation revealed a weak, yet significant association between ST and education level in persons with MS ($r=0.066$, $p=0.030$).

ST per clinical characteristics in persons with MS

Figure 1 further includes ST per clinical characteristics in persons with MS. Within the MS sample, the ANOVA revealed statistically significant differences in ST when considering MS Type ($F=21.089$, $p<0.001$) and PDDS score ($F=15.853$, $p<0.001$). When considering MS Type, the average ST was 440.0 ± 213.8 minutes per day and 548.7 ± 257.7 minutes per day in RRMS and Progressive MS, respectively. The analysis of MS type revealed a difference of 108.6 minutes of sitting per day ($d=0.5$) with persons with Progressive MS sitting more than those with RRMS. This difference was moderate according to its Cohen's d value. When considering ambulatory impairment, a Bonferroni follow up analysis indicated significant differences among all comparisons between the three groups ($p<0.05$). The average ST was 431.2 ± 203.3 minutes per day for those without ambulatory impairment, 469.8 ± 218.3 per day for those with mild ambulatory impairment and 556.2 ± 260.4 minutes per day in those with moderate-severe ambulatory impairment. Persons with mild disability spent 38.6 more minutes sitting per day ($d=0.2$) than persons without ambulatory disability, but 86.4 minutes less sitting per day than persons with moderate-severe disability ($d=0.4$). These differences were considered small according to their Cohen's d values. Persons with moderate-severe disability spent 125.0 more minutes sitting per day than persons without ambulatory impairment and this difference was considered moderate based on a Cohen's d of 0.6. There was no difference by disease duration ($F=2.064$, $p=0.127$). We confirmed the lack of associations between ST with disease duration ($r=0.045$, $p=0.140$) using a bivariate correlation.

Stepwise multiple linear regression

The regression analysis with stepwise entry was conducted to determine the sociodemographic and clinical variable(s) that independently predicted ST in the MS sample. We only included variables that explained variation in sitting behavior from the previous analyses (i.e. BMI, marital status, children, employment, education, MS Type, PDDS, and GLTEQ). The results of the regression analysis are presented in Table 2. Marital status entered in Step 1 ($R^2=0.034$, $p<0.001$), followed by GLTEQ score in Step 2 ($R^2=0.033$, $p<0.001$). Employment status entered the model in Step 3 ($R^2=0.017$, $p<0.001$), followed by PDDS in Step 4 ($R^2=0.017$, $p<0.001$). Education entered the model in Step 5 ($R^2=0.006$ for step 5, $p=0.023$). BMI, Children and MS Type did not enter into the regression model. The variables of GLTEQ, marital status, employment status, PDDS score, and education level explained 9% of variance ($R^2=0.09$) in sitting behavior.

DISCUSSION

Sedentary behavior is prevalent and problematic in developed society¹ and world-wide². We know very little about sedentary behavior in persons with chronic, disabling diseases, particularly MS. To that end, the current study compared the self-reported ST of persons with MS versus healthy controls. The primary analysis did not indicate a significant difference in ST between persons with MS and controls, even after controlling for sociodemographic variables. Both groups spent approximately 450 minutes per day, or 7.5 hours per day, sitting. Our results for persons with MS and healthy persons are generally consistent with the estimates of 8 hours and 7.7 hours spent sitting per day in previous

studies^{9,33}. This indicates that persons with MS, overall, are as sedentary as persons without MS or any other chronic condition, and developing interventions for reducing the volume of sedentary behavior is equally important in MS as the general population.

Our findings are comparable with three studies of persons with mobility disability, including Parkinson's disease³⁴, Stroke³⁵, and MS³⁶, where similar amounts of sedentary time were reported between the disabled group and the control group. One notable difference between our study and previous research³⁴⁻³⁶ is that we did not examine the way activity was accumulated throughout the day and if this was different in those with disability compared with the control group. The use of the IPAQ limited our ability to examine such differences in the way sedentary behavior is accumulated in MS, but this is an important line of future research for designing behavioral interventions. For instance, persons with Parkinson's accumulate sedentary time in longer bouts as compared to controls³⁴. Persons with stroke have half as many daily sit to stand transitions compared with controls³⁵, and those with MS have greater amounts of static activity than controls³⁶. Research with healthy non-disabled populations supports the health benefits of breaking-up long bouts of sedentary time^{5,6,37,38} (changing the pattern of activity). Accordingly, there is a strong rationale for examining the volume and pattern of sedentary behavior in persons with MS as this might inform the design of future behavioral interventions.

Interestingly, the present study indicated significant differences in physical activity levels between persons with MS and controls. The sample of persons with MS engaged in approximately 17.7 less units of physical activity than healthy controls, but physical activity was weakly associated with self-reported ST in those with MS. The difference in physical activity mirrors previous research in persons with MS³⁹⁻⁴² and furthers the notion that persons with MS are inadequately participating in physical activity. Overall, our findings demonstrate that persons with MS are less physically active, but equally sedentary based on ST, compared with controls. Our results further support the notion that physical activity and ST are relatively independent constructs¹ in MS, and sedentary behavior should not be considered the absence of moderate to vigorous physical activity⁴³. Sitting behavior might be considered an important target of interventions in MS.

The secondary analysis of the present study identified clinical and sociodemographic variables that were associated with ST in the sample of persons with MS. The results indicated that BMI, marital status, children, employment status, GLTEQ score, MS Type, and PDDS score were statistically associated with ST, whereas sex, age, race, education, income, and disease duration were not associated with ST. Our results regarding subgroups of MS are statistically significant, but do not indicate clinically meaningful differences between subgroups; there is no established value for judging clinically meaningful differences based on IPAQ ST scores. The highest amounts of ST were evident in participants with progressive MS and moderate-severe ambulatory impairment who were obese, unmarried, without children, and employed. The stepwise linear regression analysis additionally indicated GLTEQ score, marital status, employment status, education level, and disability status via PDDS score individually explained variance in ST, although collectively only accounting for 9 percent of total variance. Those with severe disability, in particular,

might have a greater burden of disease symptoms (e.g., walking dysfunction and fatigue) and this may result in a great amount of ST per day.

Of note, the ST for persons with moderate-severe ambulatory impairment (9.3 hours sitting per day), persons with mild ambulatory impairment (7.8 hours sitting per day) and persons without ambulatory impairments (7.2 hours sitting per day) was slightly lower, but of the same ratio documented in a previous study with a small sample, but with an objective outcome⁹. That study quantified sedentary time as the percentage of the day spent inactive using a Step Activity Monitor worn during the waking hours of the day in 21 persons with MS. The data indicated that, on average, 80 percent of the waking hours of the day were spent inactive, and, if we adopt a minimal wear-time of 10-hours per day, this translates into an estimated 8 hours of sedentary time per day in persons with MS. Moreover, there was a difference in sedentary time between disability levels such that those with mobility impairment spent 85% of waking hours inactivate compared with 76% of those without mobility disability. Importantly, there are notable limitations of this previous study including the small sample size, minimal comparison of sedentary time across clinical and demographic characteristics, and a non-MS control sample. Collectively, our secondary analysis identifies the subgroups of the MS population that might be important recipients for inclusion in behavioral interventions for decreasing ST⁴².

The strengths of the current study include its large sample size and inclusion of both sociodemographic and clinical variables; however, this study is not without limitations. Further, this study involved a secondary analysis of data that were collected for other primary purposes, making the study, but not data collection, retrospective in nature. This limits a focal examination of all possible determinants of ST, but does allow for a descriptive epidemiology. The current sample of persons with MS was primarily Caucasian (93%) and female (84%) with an income above \$40,000 per year (68%). The disease characteristics of this sample included mostly RRMS (90%) and a relatively low disability status based on the PDDS mean of 2.0. The current results cannot necessarily be applied to other sub-populations of persons with MS. Considering the retrospective nature of this study, there were sociodemographic differences in sex, age, BMI, employment, race, and education between persons with MS and controls, making the comparison between the two groups not ideal. Future research should consider utilizing a matched sample. Further, the control data may vary in ways unforeseen that might have influenced ST. Finally, ST was measured with selfreport and not an objective assessment, yet our estimate of ST was similar to a previous study that utilized an accelerometer to measure sedentary behavior in a small sample of persons with MS⁹. Due to the self-reported nature of our data, aspects of sitting time, such as sedentary breaks, could not be identified. Future research should aim to examine the volume and structure of sedentary time using objective measures, like accelerometry.

We believe that future researchers should identify the consequences and determinants of sedentary behavior in MS. For example, outcomes such as cardiovascular health^{4,44}, fatigue⁴⁵, and health-related quality of life⁴⁶, have been associated with sedentary behavior in healthy persons, but have yet to be examined as consequences in persons with MS. The combinatory effects of chronic disease, like MS, and sedentary behavior should be examined considering the potential for greater health problems than either alone. The identification of

possible determinants of sedentary behavior will help identify modifiable targets for future interventions designed to reduce sedentary behavior. Outcomes from such studies could inform future public policy, health initiatives, and clinical guidelines⁴⁷ in order to reduce ST in the MS population, thus decreasing this population's risk of developing comorbidities^{2,48}.

Overall, the current study indicates that self-reported ST does not differ between persons with MS and healthy controls. Nevertheless, the amount of ST in persons with MS is high (~7.5 hours/day) and ST has been associated with morbidity and mortality, independent of physical activity level, in healthy populations⁴. This suggests a future line of research directed toward decreasing ST among persons with MS through interventions and examining the secondary effects on morbidity and disease-specific manifestations².

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Figure 1.

Minutes of sitting time across sociodemographic and clinical characteristics among persons with MS. *Note:* MS: Multiple Sclerosis; PDDS: Patient Determined Disease Steps scale; BMI: Body Mass Index.

Table 1.

Sociodemographic and clinical characteristics with MS and controls. *Note:* MS: Multiple Sclerosis; RRMS: Relapsing-Remitting Multiple Sclerosis; PDDS: Patient Determined Disease Steps scale; GLTEQ: Godin Leisure-Time Exercise Questionnaire. Note: Values shown are mean $\pm$ standard deviation, unless otherwise noted.

Variable	Group		p-value
	Control (n=150)	MS (n=1081)	
Sex (% female)	91%	84%	0.01
Age (years)	43.2 $\pm$ 9.9	47.0 $\pm$ 10.3	<.001
BMI (cm/kg ²)	26.2 $\pm$ 5.8	27.7 $\pm$ 6.7	.007
Marital Status (% married)	63%	68%	0.19
Children (% with children)	72%	71%	0.76
Employment (% employed)	95%	61%	<.001
Race (% Caucasian)	82%	93%	<.001
Education (% college graduate)	81%	58%	<.001
Income (% over \$40,000)	81%	68%	0.37
MS Type (% RRMS)	-	90%	-
Disease duration (% less than 10 years)	-	61%	-
PDDS score			
- No Ambulatory Impairment (% PDDS 0-2)		47%	
- Mild Ambulatory Impairment (% PDDS 3-4)		26%	
- Moderate-Severe Ambulatory Impairment (% PDDS 5)		10%	
Time sitting (minutes)	449.6 $\pm$ 169.6	450.9 $\pm$ 220.6	0.95
GLTEQ	41.6 $\pm$ 26.7	23.9 $\pm$ 23.1	<0.001

Table 2.

Summary of hierarchical regression analysis for variables predicting sitting time in persons with MS. *Note:* MS: Multiple Sclerosis; B: unstandardized beta-coefficient; SE B: standard error of the unstandardized beta-coefficient; β : standardized beta-coefficient; GLTEQ: Godin Leisure-Time Exercise Questionnaire; PDDS: Patient Determined Disease Steps. Note: Marital status coding: 0=unmarried; 1=married; GLTEQ range: 0-198 units/day; Employment coding: 0=unemployed; 1=employed; PDDS coding: 0=no ambulatory impairment; 1=mild ambulatory impairment, 2=moderate ambulatory impairment; Education coding: 1=less than 7th grade, 2=9th grade, 3=partial high school, 4=high school graduate, 5=1-3 years of college, 6=college/university graduate, 7=master's degree, 8=PhD or equivalent. $R^2 = 0.034$ for step 1, $p < 0.001$; $R^2 = 0.033$ for step 2, $p < 0.001$; $R^2 = 0.017$ for step 3, $p < 0.001$; $R^2 = 0.017$ for step 4, $p < 0.001$; $R^2 = 0.006$ for step 5, $p = .023$.

Step	Variable	B	SE B	β
Step 1	Marital Status	-85.28	16.45	-0.19
Step 2	Marital Status	-85.77	16.18	-0.19
	GLTEQ	-1.81	0.35	-0.18
Step 3	Marital Status	-87.42	16.05	-0.19
	GLTEQ	-1.92	0.35	-0.19
	Employment	57.73	15.64	0.13
Step 4	Marital Status	-85.16	15.92	-0.19
	GLTEQ	-1.74	0.35	-0.17
	Employment	78.71	16.46	0.18
	PDDS	47.41	12.53	0.14
Step 5	Marital Status	-85.02	15.88	-0.19
	GLTEQ	-1.79	0.35	-0.18
	Employment	73.64	16.57	0.17
	PDDS	48.88	12.51	0.15
	Education	-34.78	15.22	-0.08