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Examining Age-Related Differences in Functional Domain Impairment Following Traumatic Brain Injury

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Abstract

Objective—To examine differences in the functional recovery trajectories between younger and older adults with mild-moderate traumatic brain injury (TBI) in the first year post-injury as well as health-related quality of life.

Design—Observational cohort.

Setting—Level one trauma center in the State of Washington.

Participants—Adults with mild-moderate TBI (N=34; younger adults, n=19, and older adults, n=15).

Interventions—None.

Main Outcome Measures—Functional Status Examination (FSE) and health-related quality of life (HRQOL; SF-12v2).

Results—Older adults consistently showed significantly worse functional performance than younger adults following TBI in the following FSE domains: mobility, ability to travel, home maintenance, and overall functional status. For both groups, pre-injury physical health was

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significantly correlated with ability to travel and social integration at 12-months post-injury. Older participants' pre-injury physical and mental health had significant and negative correlation with their functional status.

Conclusions—Our study provides insights and implications into adults' specific functional impairments following TBI, and which domains have persistent deficits. Early intervention and rehabilitation should focus on improving older adults' physical functioning and mobility. Our study may also inform future research and design of post-TBI interventions for older adults.

Keywords

Head Injury; Aged; Functional Status; Health-related Quality of Life; Recovery

Introduction

Globally, traumatic brain injury is a leading cause of death and disability. In the United States, traumatic brain injury (TBI) affects roughly 3.5 million individuals annually (MacDonald et al., 2017). Survivors of traumatic brain injury (TBI) often experience injury-related impairments that negatively affect their day-to-day activities, and in some cases, increases their reliance on others to provide assistance (Centers for Disease Control and Prevention, 2014). Adults 65 years and older may be at increased risk for severe disability following TBI because of pre-existing conditions, decreased pre-injury activity levels, and progressive neurophysiologic deterioration (Failla, Conley, & Wagner, 2016; Gardner, Dams-O'Connor, Morrissey & Manley, 2018; Thompson, McCormick & Kagan, 2006). Despite evidence that older adults following TBI are more likely to have lower Glasgow Outcome Scores than their younger counterparts with similar injuries (Mosenthal, et al., 2002), little is known about the specific impairments experienced over time. A better understanding of and the ability to predict the trajectory of disability among older adults following TBI is needed (Dams-O'Connor, Gibbons, Landau, Larson & Crane, 2016) in order to aid to nurses and other clinicians who aim to diminish the problem of TBI-related disability in the older adult.

Dikmen and colleagues (2001) developed the Functional Status Examination (FSE) to evaluate changes in everyday living across physical, social and psychological domains. The FSE has been shown to have good test-retest reliability ($r=0.80$) as well as high correlation of proxy to subject report ($r=0.76$)⁵ and ability to assess for changes to 5 years post-injury. Limited studies to date have included examined age and specific domains of functional status post-TBI (Powell, Temkin, Machamer & Dikmen, 2007; Wise, Mathews-Dalton, Dikmen, Temkin, Machamer, Bell & Powell, 2010). No association was found between increasing age (> 40 years) and ability to participate in leisure activities via FSE at 1-year post-injury (Wise et al., 2010). Powell and colleagues (2007) used the FSE to examine home management at one year post-injury and found that adults 65–89 years of age ($n=7$) were more likely than younger colleagues ($n=153$) to be dependent or require some help with home management activities (e.g., cleaning, home repair, yard care). However, these studies are limited by the lack of longitudinal assessment of function over time, choice of age cutoffs as well as understanding the relationship between pre-morbid functioning and health-related quality of life on function post-injury. The purpose of the present report is to address some of these gaps by: (1) describing the trajectory of change in overall functional

performance as well as its specific domains in younger and older adults to 1-year post injury using the FSE and (2) examining the relationship between functional performance and pre-injury health-related quality of life (HRQOL) in these groups.

Methods

We conducted secondary analysis from a prospective cohort study that recruited younger (n=19) and older adults aged 65 years old and a (n=15) within 24 hours of mild-moderate TBI (defined as Glasgow Coma Scale Score (GCS) of 9–15; Teasdale & Jennett, 1974). The purpose of the parent study was to describe the relationship between selected inflammatory markers and symptom and functional outcomes following TBI in older adults. Participants with TBI were recruited during daytime hours 3 days a week from a Level one trauma center in Seattle, Washington from 2009–2010. A total of 280 patients were screened, and 72 subjects were approached for participation during the study (See Figure 1 for Study Screening/Enrollment). Exclusion criteria were (1) lower extremity fracture or cervical spine trauma at time of injury; (2) previous head injury in the past 30 days; (3) previous hospitalization for a psychiatric disorder, (4) diagnosis of dementia; (5) regular steroid or non-steroidal anti-inflammatory use that would have interfered with inflammatory biomarker measurement; (6) prisoner status. A trained member of the research team approached participants or their legally authorized representative (LAR) to obtain informed consent of participants with TBI within 24 hours of injury. Once informed consent was obtained, a member of the research team extracted information from the medical record on type of brain injury, and comorbid health conditions. Demographic information was obtained from the subject or LAR at enrollment and injury related information were extracted from the medical record and verified with the trauma registry. Participants whose LAR had initially provided consent to participate (n=3) were able to be re-consented during the first week post-injury. Trained research assistants conducted interviews with participants to obtain answers to questionnaires regarding recovery to one year following TBI.

To address the present study's aims, data included from the parent study were demographics at time of study entry (age, gender, and race/ethnicity), pre-injury HRQOL as well as functional status at 3, 6 and 12 months post-injury. Initial injury severity was measured by 1) the GCS in the Emergency Department and 2) Injury Severity Score (ISS) both verified by the hospital trauma registry. The ISS is the sum of the squares of the most severe injury in each of the three most severely injured body regions (Baker, O'Neill, Haddon, & Long, 1974). The six body regions on which the ISS is based are head/neck, face, chest, abdomen/pelvic contents, extremities/pelvic girdle, and external. The ISS is scored on a scale of 1 (least severe) to 75 (most severe), scores of 14 or higher indicate moderate injury (Baker & O'Neill, 1976).

Health-Related Quality of Life (HRQOL) was measured at time of enrollment or when cognitively able to respond (within first week of injury) using the Health-related Quality of Life Short Form-12v2 (SF-12v2), a 12-item scale that measures HRQOL for the past week. To assess pre-injury HRQOL, we asked participants to respond to the items to indicate their HRQOL in the week *prior to* injury. We computed and weighted the scores based on the SF-12v2 scoring manual (Ware, Keller & Kozinski, 1998). Scores are on a range of 0–100

with higher score indicating better health status, 50 is considered the average. Subscales for physical component (PCS) and mental component (MCS) are produced (Ware, Kosinski, & Keller, 1996). There is no cut-off value to determine the level of individual's quality of life and the scores tend to vary for different age groups. For example, PCS tends to decrease with age, while MCS tends to increase. It has been validated for use in TBI patients (Findler, Cantor, Haddad, Gordon, & Ashman, 2001).

Functional status was measured at 3, 6 and 12-months post-injury using the 12-item Functional Status Examination (FSE), gathered through a structured interview. The areas of functioning assessed include physical (personal care, mobility, ability to travel), social (work/school, home maintenance, leisure/recreation, social integration, standard of living), and psychological domains (executive functioning, financial independence; Dikmen, Machamer, Miller, Doctor & Temkin, 2001). For each domain, outcome is rated by a 4-point Likert scale with lower scores associated with better outcome.

Statistical Analysis

The data included in the analysis was from all of the participants with TBI who enrolled in the original study. Three sets of analyses were implemented. First, descriptive analysis was performed to describe the characteristics of the participants and one-way ANOVA was performed to examine the baseline differences between older and younger adult groups. Second, the functional changes over time between younger and older adults following TBI were analyzed by repeated measures ANOVA with Bonferroni post-hoc tests. Third, regression analyses were used to examine the relationship between all participants' pre-injury HRQOL (separate models built for the physical (PCS) and mental health (MCS) components) and their functional performance (each item in FSE) at 3, 6, 12 months. A p -value $< .05$ was the criterion to determine statistical significance.

Results

This study analyzed FSE data and pre-injury HRQOL data in both groups of younger adults ($n=19$) and older adults ($n=15$) following mild-moderate TBI (Please see Table 1). The most commonly experienced type of TBI was concussion (41.2%), with negative findings on head CT. For those subjects who did have a positive head CT ($n=20$), the most common findings were traumatic subarachnoid hemorrhage (45%), subdural hematoma (35%), skull fracture (35%), contusion (20%) and epidural hematoma (20%). There was a significant between-group difference in gender ($p = .006$), more males in younger adult group than in the older adult group. There was no difference in pre-injury quality of life between older and younger adult groups ($ps > .05$) while older group scored lower on the physical health scale. Comparing with the national norm in the U.S., the younger group are above average (mean=51.5) while the older group are below average (mean = 40.5) in their perceived physical health related quality of life. For the mental health relate quality of life, both groups are below average (mean= 30.6; 30.1).

Differences in functional performance between younger and older adults with TBI over time

Older adults consistently showed significantly worse functional performance than younger adults following TBI in the following domains: mobility, ability to travel, home maintenance, and overall functional status (Table 2). For older adults, significant functional declines were observed in the domain of personal care and overall functional status over time compared to younger adults, especially during the 6–12 month follow-up period (Table 2). In both age groups, functional mobility was positively associated with the ability to travel ($r = .69$), home maintenance ($r = .70$), and social integration ($r = .66$; $ps < 0.01$).

The relationship between pre-injury quality of life and functional performance

For all subjects, pre-injury physical health (PCS) was significantly associated with ability to travel ($p = .02$; $R^2 = .28$; $F = 4.27$; $b = -.44$) and social integration ($p = .01$; $R^2 = .26$; $F = 3.84$; $b = -.54$) at 12 month post-injury. However, better pre-injury PCS was significantly associated with better home maintenance ability ($ps < .05$; $R^2 = .34-.45$; $F = 7.09-8.94$; $b = -.47-.56$) and better overall functional performance ($ps < .05$; $R^2 = .21-.42$; $F = 4.26-9.55$; $b = -.43-.47$) across all time points (3, 6, 12 months). A better mental quality of life (MCS) prior to injury was moderately associated with worse functional performance in ability to travel at 3 ($p = .048$; $R^2 = .37$; $F = 8.26$; $b = .34$) and 6 months post-injury ($p = .01$; $R^2 = .41$; $F = 9.23$; $b = .45$).

We also examined the correlation between each FSE domain and pre-injury physical and mental health by age group (Tables 3A and 3B). Overall, for older adults, higher quality of life prior to injury was associated with better functional status. Specifically, higher physical quality of life at was associated with better ability to perform home maintenance in older adults at each time point ($ps < .05$). While in younger adults, pre-injury PCS was only correlated with executive functioning ($p = .001$; $R^2 = .59$; $F = 19.67$; $b = -.79$) at 3 months post-injury. Higher MCS prior to injury was associated with worse functional status in older adults at 3-month post-injury ($p < .05$; $R^2 = .43$; $F = 9.44$; $b = .70$). At 6-month time point, higher pre-injury MCS was associated with worse functional outcomes in six domains (travel, home maintenance, leisure/recreation, social integration, executive functioning, and overall functional performance) among older adults ($ps < .05$; $R^2 = .30-.68$; $F = 5.17-22.01$; $b = .60-.86$). On the other hand, for younger adult group, better pre-injury MCS was associated with better 6 month social integration functioning ($p = .011$; $R^2 = .38$; $F = 9.04$; $b = -.66$). At 12 months post-injury, the significant association between pre-injury quality of life and functional status only occurred to older patients. For example, in addition to the continuous significant association between PCS and home maintenance functioning, higher PCS at pre-injury was associated with better social integration ($p = .04$; $R^2 = .39$; $F = 5.72$; $b = -.62$). Better pre-injury MCS was associated with worse travel ($R^2 = .45$; $F = 9.09$), home maintenance ($R^2 = .31$; $F = 5.49$), and overall functioning ($R^2 = .46$; $F = 9.49$) at 12 months post-injury (all $p < .05$).

Discussion

As our society ages, the number older adults living with TBI increases; however, there is a limited number of studies examining older adults' functional performance following TBI

and their unique rehabilitation needs. In the present report, older adults showed significantly and consistently worse functional performance than younger adults in the following functions: mobility, ability to travel, home maintenance, and overall functional status to one year post-injury. These results are consistent with other studies that show older adults tend to have worse physical outcomes after a TBI due to a decreased ability to recover from neural insult; this is compounded by decreased physical activity in the immediate/acute recovery phase (Cuthbert, Harrison-Felix, Corrigan, et al. 2015; Howrey, Graham, Pappadis, Granger & Ottenbacher, in press). Our results suggest that early intervention and rehabilitation should focus on improving older adults' mobility. Tiedemann and colleagues (2013) found that balance and mobility improved among older adults engaged in a low-impact exercise regimen (yoga) when compared to their control group. Furthermore, our results showed that mobility and social health are positively correlated; this further highlights the importance of focusing care efforts on preventing mobility decline. Reconciling home maintenance needs is an important start because perceived barriers to mobility at the entrances to homes of older adults have been found to be associated with daily mobilization¹; therefore examination and adaptation of home environments and the older adults perception of the environment should be considered post-injury. After a TBI, inviting members of the older adults' social network to participate in leisure activities have also been shown to simultaneously enhance social health and physical mobility (Chang, Wray & Lin, 2014).

Quality of life (including physical health and mental health) measured by the SF-12 prior to injury plays an important role in overall functioning performance following TBI. We found that in both age groups, better pre-injury physical health condition was associated with a better overall functioning performance and home maintenance ability across time points. However, SF-12 MCS correlated differently with the functional status in different age groups. For older adults, better pre-injury MCS was associated with worse functional outcomes. This finding has not been examined in other studies on patients with TBI, but has been investigated in studies on patients with lumbar degenerative disc disease (Stiene et al., 2017). Stiene and colleagues found in both healthy persons and older patients with the average age over 55 years old, there was a significant increase in functional impairment with every increase in the quartile of the SF-12 MCS. It appears that the association is independent from the underlying disease. While co-morbidities have been shown to complicate functional outcome after TBI, the evidence is still emerging for the protective quality of exceptional physical health and mental resilience (Holland & Schmidt, 2015). Additionally, in experimental models better functional outcomes were evident in animals post-injury who underwent exercise regimens before brain injury (Zhao, Sabirzhanov, Wu, Faden & Stoica, 2015). Pre-injury HRQOL can be used a screening tool for healthcare providers to identify patients who will likely have greater needs in during recovery and rehabilitation for targeted intervention.

Limitations of the present study include a modest sample size, covariates such as the variability of the injury, the lack of post-injury care provision (such as physical therapy) and the inclusion of only Caucasians in the sample. Future studies need to include individuals from wider ethnic/racial backgrounds as well as a larger sample size so that other covariates can be included in analyses. Further, studies should assess what services patients receive

post-injury and in what “dose” in order to assess the impact of access to care on function post-injury, particularly in the older age group.

Conclusions

Our study provides insights and implications into adults’ specific functional impairments following TBI, and which domains have persistent deficits. This may inform future research and design of post-TBI intervention for older adults. However, results of our study are limited in generalizability by the small sample size as well as lack of information available on how resource utilization and participation in specific therapies may have modified functioning over time.

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Summary Statement of Implications for Practice

What does this research add to existing knowledge in gerontology?

- Identifies specific domains of function that are impaired in older adults with mild traumatic brain injury to one year post injury.

What are the implications of this new knowledge for nursing care with older people?

- Identifies specific targets for assessment and rehabilitation (mobility, ability to travel outside the home, and home maintenance) that nurses caring for this population should address.
- Examination and adaptation of home environment should be considered post-injury because perceived barriers at the entrances to homes of older adults have been found to be associated with daily mobilization.

How could the findings be used to influence policy or practice or research or education?

- Pre-injury physical condition can be used for screening at time of injury to identify patients have greater needs in during recovery and rehabilitation.
- Further examination of the role of resource utilization and participation in specific therapies on functional status needs to be explored.

Figure 1. Study Screening and Enrollment Diagram from Parent Study. The most common reason for declining participation was “did not want blood draws”.

Table 1

Characteristics of Sample. Reported in percent except as noted.

	Younger TBI N=19	Older TBI N=15	Between Group Comparison ^a
Age (mean(SD), range)	38.74(12.0) 23–63	77.5(9.1) 65–91	
Gender			.006*
Male	16(84.2%)	6(40%)	
Female	3(15.8%)	9(60%)	
Race n(%)			
White	19(100.0)	12(25.5)	
Asian/Pacific islander	0(0.0)	1(6.7)	
More than one race	0(0.0)	2(13.3)	
Glasgow Coma Scale mean, (SD)	14.5 (1.5)	14.5 (1.3)	.81
Injury Severity Score mean (SD)	18.4 (9.3)	17.3 (9.4)	.72
Pre-injury Physical Quality of Life mean(SD)	51.46 (.79)	40.52 (.57)	.189
Pre-injury Mental Quality of Life mean(SD)	30.6 (1.6)	30.1(1.2)	.587

Table 2

The Trajectory of Functional Impairments by Age Group

Variable	Age Group	3 Months Mean (SD)	p^a	6 Months Mean (SD)	p^a	12 Months Mean (SD)	p^a	3-6mo F/p^b	6-12mo F/p^b	3-12mo F/p^c
Physical Domain										
Personal Care	Younger	.13 (.35)	.04 *	0	.12	0	.003 **	.64/.431	9.59/.005 *	3.36/.056
	Older	.69(.95)		.42 (.99)		.82 (.98)				
	Younger	.40 (.91)	.01 *	.20 (.56)	.01 *	.07 (.26)	<.001 ***	.01/.93	.28/.603	.52/.566
Mobility	Older	1.23 (.73)		1.08 (1.08)		1.18 (.75)				
	Younger	.20 (.78)	.001 **	.13(.52)	.01 *	.33(.90)	.004 **	1.47/.236	.37/.547	.30/.740
	Older	1.62(1.26)		1.17 (1.34)		1.64 (1.21)				
Social Domain										
Home Maintenance	Younger	.40 (.91)	.04 *	.47 (.92)	.01 **	.40 (.91)	.01 *	.36/.553	.02/.880	.25/.773
	Older	1.31(1.25)		1.58(1.08)		1.45 (1.13)				
	Younger	1.20(1.37)	.71	1.30(.34)	.46	1.22(.32)	.09	.29 /.597	2.06/.164	1.17/.320
Leisure/Recreation	Older	1.38(1.19)		1.36(.39)		.75(.23)				
	Younger	.20 (.56)	.01 *	.33 (.72)	.14	.40(.91)	.02 *	.01/.351	2.83/.10	1.77/.189
	Older	1.08(1.12)		.92 (1.24)		1.36 (1.12)				
Social integration	Younger	.60(.83)	.67	.47(.83)	.93	.27(.70)	.54	.30/.586	2.76/.109	2.18/.126
	Older	.46 (.88)		.50 (1.00)		.45 (.82)				
Psychological Domain										
Executive Functioning	Younger	.53 (.83)	.12	.33 (.62)	.09	.47 (.83)	.09	.05/.828	.37/.547	.15/.840

Variable	Age Group	3 Months Mean (SD)	p^a	6 Months Mean (SD)	p^a	12 Months Mean (SD)	p^a	3–6mo F / p^b	6–12mo F / p^b	3–12mo F / p^c
Financial Independence	Older	1.08(.95)		.83 (.84)		1.09(.94)				
	Younger	.73 (1.16)	.79	.60(1.12)	.61	.53(1.06)	.98	.51 /.482	.01/.925	.40/.633
	Older	.62 (1.12)		.83(1.19)		.55(1.04)				
Overall functioning	Younger	4.40 (5.99)	.02 *	3.40 (5.55)	.02 *	3.53 (5.76)	.002 **	.00/1.00	5.66/.026 *	3.10/.06
	Older	9.46 (6.85)		8.58 (6.24)		10.36 (4.99)				
Overall functioning plus work and school	Younger	5.07(6.89)	.04 *	3.87 (6.56)	.03 *	4.20(6.77)	.007 **	.03/.870	4.46/.045 *	2.72/.08
	Older	9.69(7.17)		8.83 (6.37)		10.82(5.40)				

Note:

a : Independent sample t-test;

b : One-way ANOVA;

c : Repeated measurement ANOVA;

* <.05;

** <.01;

*** <.001;

d : overall functioning is the total score of FSE

Table 3

A: The Relationship Between Pre-Injury Physical Quality of Life (SF-12v2-PC) and Functional Impairments Changes Over Time.

Variable	Age Group	Pre-Injury Physical Quality of Life			
		3 Months <i>b</i>	<i>p</i>	6 Months <i>b</i>	<i>p</i>
Physical Domain					
Personal Care	Younger	-.37	.20	--	--
	Older	-.53	.08	-.33	.34
Mobility	Younger	-.33	.25	-.34	.23
	Older	-.14	.67	-.30	.37
Travel	Younger	-.24	.40	-.24	.40
	Older	-.28	.37	-.26	.44
Home Maintenance	Younger	-.47	.09	-.49	.07
	Older	-.64	.02 *	-.61	.048 *
Leisure/Recreation	Younger	-.12	.68	-.14	.62
	Older	-.42	.18	-.24	.47
Social integration	Younger	-.34	.23	-.22	.45
	Older	-.01	.97	-.20	.56
Standard of Living	Younger	-.36	.21	-.36	.21
	Older	-.08	.80	-.28	.41
Psychological Domain					
Executive Functioning	Younger	-.79	.001 *	-.51	.07

A: The Relationship Between Pre-Injury Physical Quality of Life (SF-12v2-PC) and Functional Impairments Changes Over Time.

Variable	Age Group	Pre-Injury Physical Quality of Life					
		3 Months		6 Months		12 Months	
		<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>
Financial Independence	Older	-.23	.47	-.43	.19	.003	.99
	Younger	-.22	.46	-.34	.24	-.34	.23
	Older	-.35	.27	-.16	.64	-.05	.87
Overall functioning	Younger	-.43	.12	-.38	.19	-.47	.09
	Older	-.42	.17	-.49	.12	-.57	.07
	Younger	-.43	.13	-.18	.55	-.20	.49
Overall functioning plus work and school	Older	-.43	.16	-.52	.10	-.54	.08

B: The Relationship Between Pre-Injury Mental Quality of Life (SF-12v2-MC) and Functional Impairments Changes Over Time.

Variable	Age Group	Pre-Injury Mental Quality of Life					
		3 Months		6 Months		12 Months	
		<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>
Physical Domain							
Personal Care	Younger	-.40	.16	--	--	--	--
	Older	.20	.53	.18	.59	.16	.63
Mobility	Younger	-.47	.09	-.43	.13	-.34	.17
	Older	.31	.33	.45	.17	.48	.14
Travel	Younger	-.39	.17	.84	.001*	-.29	.32
	Older	.80	.002*	-.39	.17	.71	.01*
Home Maintenance	Younger	-.40	.16	-.44	.11	-.40	.16

B: The Relationship Between Pre-Injury Mental Quality of Life (SF-12v2-MC) and Functional Impairments Changes Over Time.

Variable	Age Group	Pre-Injury Mental Quality of Life					
		3 Months <i>b</i>	<i>p</i>	6 Months <i>b</i>	<i>p</i>	12 Months <i>b</i>	<i>p</i>
	Older	.60	.041 *	.71	.014 *	.62	.04 *
Leisure/Recreation	Younger	-.22	.46	-.33	.25	-.20	.50
	Older	.70	.012 *	.61	.048 *	.37	.27
Social integration	Younger	-.43	.13	-.66	.011	-.33	.25
	Older	.72	.008 *	.60	.049 *	.49	.13
Standard of Living	Younger	-.25	.39	-.24	.41	-.40	.16
	Older	.15	.65	.36	.28	.19	.58
Psychological Domain							
Executive Functioning	Younger	-.20	.49	-.37	.19	-.22	.46
	Older	.61	.034 *	.58	.06	.46	.16
Financial Independence	Younger	-.09	.75	-.24	.41	-.35	.23
	Older	.22	.49	.16	.63	.09	.79
Overall functioning	Younger	-.37	.19	-.44	.12	-.36	.21
	Older	.70	.012 *	.84	.001 *	.72	.013 *
Overall functioning plus work and school	Younger	-.35	.22	-.27	.36	-.25	.38
	Older	.70	.011 *	.86	.001 *	.71	.015 *

Note:

b : coefficient;

* <.05