Original Article (short paper)

Motor control assessment of community-dwelling older adults with depressive symptoms

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Abstract — Aims: The purpose of this study was to investigate how depressive symptoms mediate different motor control requirements in elderlies and to assess the concurring effects fomented by the interaction between aging and depressive symptoms, providing indirect measures of brain functionality. **Methods**: Sixty-eight elderlies were paired in terms of age and gender and were equally distributed into depressed and nondepressed groups, according to their score on the Beck Depression Questionnaire. The participants performed the Grooved Pegboard Test placing and withdrawing pegs while execution time and error rate were measured. **Results**: This investigation revealed that depressive symptoms exert a broad effect upon motor control, although that the symptom intensity, as well as the interaction between aging and depression intensity, were exclusively correlated with withdrawal task, suggesting that there is a greater effect upon motor acts with higher frontal lobe requirements. **Conclusion**: The discrimination of motor control aspects provides a valuable contribution for the understanding of the underlying neurophysiology of the interaction between aging and depression as it represents an indirect measure of cerebral dysfunction. Further, these findings may still have clinical implications, as they can promote more rational approaches to the elaboration of preventive measures that help maintain the functional capability of depressed elderlies.

Keywords: aging, depression, psychomotor, psychiatric disorders, elderly, hand function.

Introduction

Over the past few years, a growing body of evidence has demonstrated that depression disorders are gaining relevance in disease prevention and health promotion[1,2]. Specifically, as the population ages, the economic impact of neuropsychiatric disorders is expected to grow significantly[3], posing a considerable public health problem[4,5]. Depression symptoms not only include mood alterations but an array of other disorders, including apathy, anedonia, vegetative symptoms and cognitive dysfunction, which can severely impact the quality of life of the elderly and their ability to deal with many activities of daily living[6,7].

It is common knowledge that aging impairs the maintenance of functional capability as well as several domains of the cognitive segment. However, the notion that depression is also associated with alterations in regions of the brain that are not related to mood control, was acknowledged only in the last few decades[8]. Specifically, neuroscience-based inquiries have demonstrated depression influences several areas of the brain, such as the prefrontal and orbitofrontal cortices, anterior cingulate, amygdala, and the hippocampus[9,10]. Consequently, impairments over executive functions[11-13], processing speed[14-16], and episodic memory may occur as a function of depression, impairing everyday functioning[12,17].

Most cognitive impairments associated with depression have a strict relationship with motor control. These consequences, usually termed as psychomotor abnormalities, encompass the engagement of cognitive-control mechanisms into a motor act[18] and have been commonly explored by measures concerning processing speed, such as reaction time or the control of spatial-temporal parameters (see Bennabi, Ugrinowitsch, Apolinario-Souza, Vieira, Albuquerque and Benda[19] for a more detailed review). These measures were included in different analyses, such as gait[20,21], drawing tasks[22,23] and eye movements[24,25]. Because motor slowness was frequently reported in these studies, the impairments over motor control have been considered a common feature of depressed individuals and comprises a great focus of research in the last years. Summarily, these studies have aimed to uncover the influences of depression on motor control in young adults, despite that some of them omitted the medication status of the sample[20,26] or were under medication[22], which might have biased the intended behavior. To our knowledge, Beheydt, Schrijvers, Docx, Bouckaert, Hulstijn and Sabbe[27] were the only who demonstrated that unmedicated depressive older adults presented motor control impairments in comparison to their nondepressed peers. Promising results were observed as they revealed that the execution and initiation times were significantly impaired according to the manipulation of the cognitive load of a figure copying task[27].

The distinction of motor control aspects, on the other hand, is extremely relevant to understand the issues related to the interaction between aging and depression since it can provide an indirect measure of different brain dysfunctions[28]. According to the classic Woodworth concepts[29], which are still followed by several recent researches[28,30-33], it is possible to discriminate motor control aspects manipulating the required time on a motor task. More precisely, ballistic motor actions don't require much input of sensory information and rely mainly on a pre-programmed phase (planning; *initial impulse phase*) unlike movements that are slower which engage high feedback processing (online control of motor actions; *current control phase*). Therefore, by manipulating different motor control requirements, we may, indirectly, reveal impairments specifically linked to different brain areas.

Further, the estimation of the intensity of depression is also of fundamental concern to the understanding of the interaction between aging and depression since it has been reported as one possible source of variation in the degree of cognitive impairment[27,34]. Sex is another factor that might influence the movement planning and control of depressed elderlies. Specifically, Fernandes, Ugrinowitsch, Oliveira, Bicalho and Lage[35] have recently demonstrated that response strategies in aiming control are influenced by sex in different task constraints. Still, neurobiological differences (dimorphisms) have been observed in many neurological domains (see Sacher, Sacher, Neumann, Okon-Singer, Gotowiec and Villringer[36] for a review) which reveal that sex is also a relevant subject in the inquiries of neuroscience and consequently, in motor control.

Overall, the discrimination of different aspects involved in the motor control of elderlies with depressive symptoms can bring useful information regarding the interaction between aging and depression. Particularly, we expect to confirm that depressed older adults present more prominent impairments in the most complex task, (i.e., the peg placement task), and further, unravel distinct associations with their motor performance.

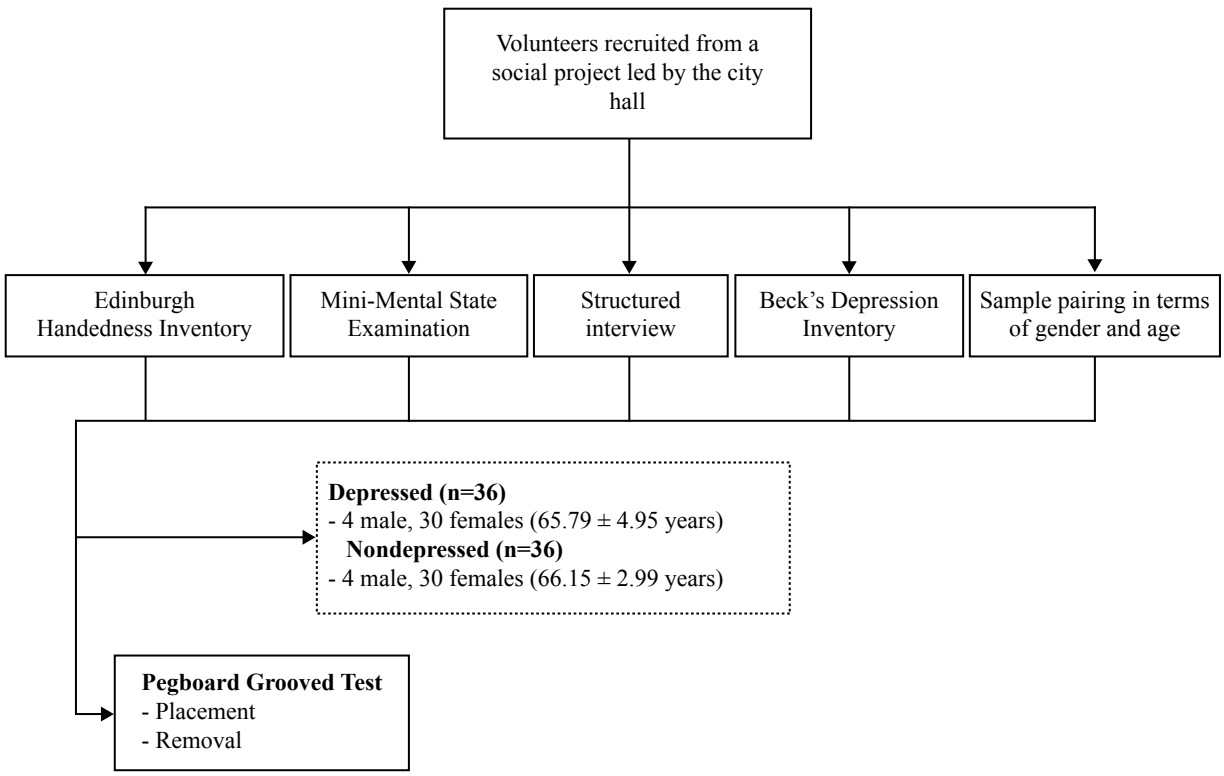
Material and Methods

Participants

Older adults, who were originally participating in a social project headed by the local city hall, were invited to participate in this study. Firstly, the volunteers were submitted to a structured interview in order to exclude individuals with previous history of psychiatric disorder, neurological disease, with uncorrected or abnormal vision or using medication that might impair motor control. Also, the level of education of the volunteers was measured according to years of study. The Edinburgh Handedness Inventory (EHI)[37] was then applied to determinate the participant's laterality index and to exclude individuals who presented a preference index of 70 points or below. Subsequently, the Mini-Mental State Examination (MMSE)[38] was employed to screen dementia cases, excluding individuals who scored less than 24 points[39] . The Beck Depression Index (BDI)[40] was then applied for the assessment of depression symptoms and to allocate participants into two groups, depressed elderlies (DE) or nondepressed elderlies (NE), according to their score, following the cut-off point for mild depression (10)[41,42]. The BDI is a self-evaluation scale which is used worldwide in the general population and in primary care[43]. Is easy to administer, is inexpensive[44] and is considered one of the most commonly used scales for identifying the severity of depression symptoms.

After the exclusion of individuals who didn't meet the proposed criteria, 34 individuals (65.47 ± 3.14 years) with a score equal to or higher than 10 (mild symptoms and above) on the BDI were allocated into DE. Then, thirty-four individuals who paired in terms of level of education, age (65.35 ± 5.13 years) and gender (4 males and 30 females) and presented a score lower than 10 on the BDI were allocated as controls (Figure 1).

Figure 1. Flowchart overview of sample selection and experimental procedures.

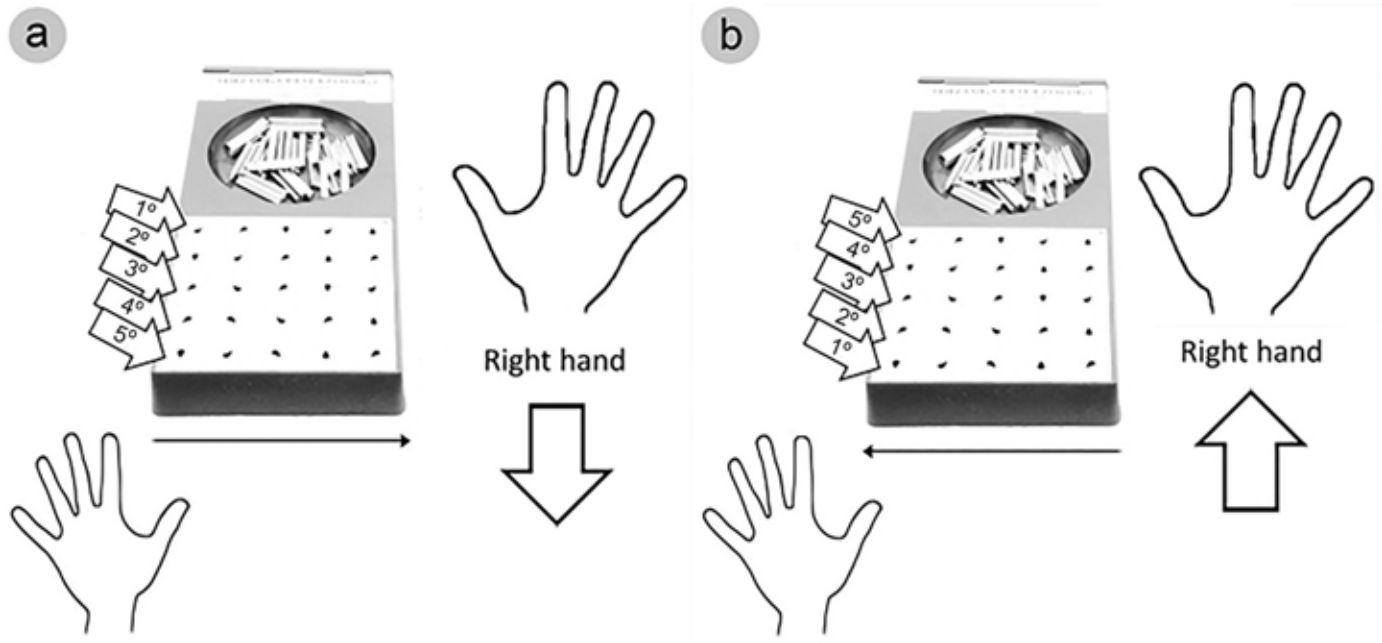


After the sample selection, all volunteers were oriented regarding the experimental procedures and signed a consent form before joining the study, which was conducted in accordance with the Declaration of Helsinki, and was approved by the local Ethics Committee (CEP-FUMEC 03/2011). All participants gave written consent for participation.

Experimental procedures

After the sample selection, the participants were oriented concerning the experimental tasks procedures. Specifically, the participants were asked to take 25 pegs (1 mm diameter and 25 mm length) placed on a receptacle, and place them in the row of holes of the pegboard, or withdraw the pegs from the pegboard to the receptacle as quickly as possible and in a standardized, prescribed order (place and withdraw pegs from left to right using their right hand). The Pegboard Grooved Test (Lafayette Instruments # 32025) was then applied in both groups to analyze the motor control of the volunteers (Figure 2). Each condition was repeated and the order of execution was randomized. The tests and interviews were conducted in the residences of the volunteers.

Figure 2. Schematic representation of the prescribed order of peg placement (a) and withdrawal (b) on the Grooved Pegboard Task. Adapted from Salvador et al.54



With the assistance of a chronometer, participants were timed during the GPT execution for both tasks (placement and withdrawal). Specifically, the time between the start stimulus until the placement/withdrawal of the last peg was measured as execution duration. Execution errors, which include attempts in which the pins fell during placement/withdrawal, and order errors, were also measured by the experimenter. Furthermore, the association of motor control measures with depression symptoms, depression intensity, and the interaction between aging*depression intensity were determined with correlation analysis performed in a statistical software package.

Statistical analysis

For all motor control variables, data from two trials of each condition were averaged for each participant. Then, the homogeneity of variances was verified with a Shapiro-Wilks test and subsequent tests were chosen accordingly. Mann-Whitney U-tests were used to test overall group differences regarding mean values of execution time and errors for both tasks, and for sex differences. Spearman's rank correlation coefficients were computed to assess the association between the presence of depressive symptoms, depression intensity, and the interaction between aging and depression intensity with motor control variables. Statistical analysis was conducted with SPSS 23.0 for Windows (Statistical Package for Social Sciences, Chicago, IL, USA) and $\alpha \leq .05$ was used as significance criterion.

Results

Sample characteristics

No differences in terms of age ($F_{1,66}$=.127 p=.723), level of handedness (EHI; $F_{1,66}$=3.873, p=.053) and cognitive status (MMSE;

$F_{1,66}$=1.086, p=.301) were revealed between groups. In sum, non-depressed older adults presented a range of 0 to 9 of depression intensity on the BDI questionnaire, 80-100 on EHI, and 24-30 on MMSE; depressed elderlies presented a range of 10 to 50 on BDI, 80 to 100 on EHI, and 24-30 on MMSE. Descriptive statistics for the entire sample are represented below on Table 1.

Table 1. Demographic characterization of depressed and non-depressed participants. Comparisons between groups were performed with univariate analysis of variance (ANOVA). *$p \leq .05$; **$p \leq .01$

	Participants		
	Nondepressed		**Depressed**
Age (years)	66.15 ± 2.99		65.79 ± 4.95
Beck Depression Inventory	5.38 ± 2.24	**	16.94 ± 9.46
Edinburgh Laterality Index	99.12 ± 3.79		97.94 ± 5.38
Gender	30 ♀ / 4 ♂		30 ♀ / 4 ♂
Mini-Mental State Examination	29.03 ± 1.98		28.38 ± 1.61
Years of education	7.41 ± 4.44		7.94 ± 4.01

epressed elderlies (c). *p ≤ .05; **p ≤ .01

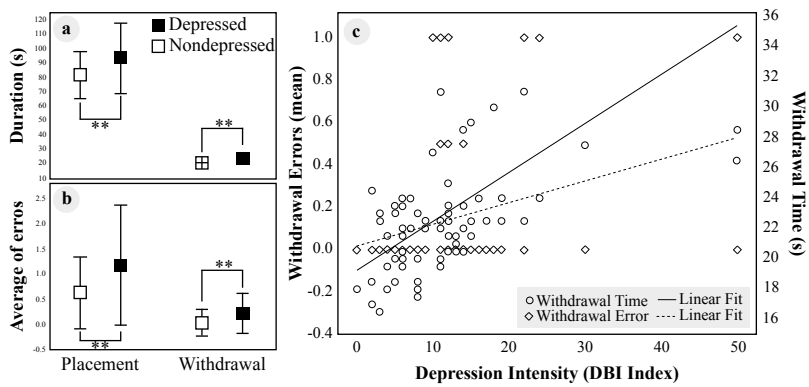
Pegs placement

According to the Mann-Whitney U-test, depressed older adults presented a longer execution duration of peg placement (MWU=349, Z=-2.810, p=.005) (Figure 3A) and a higher amount of errors (MWU=383.0, Z=-2.472, p=.013) (Figure 3B) than their non-depressed peers. Separate analysis revealed that the results can't be partially attributed to sex differences. Mann-Whitney U-test analysis revealed no differences between males and females regarding peg placement duration (MWU=152.5, Z=-1.666, p=.096) and peg placement error (MWU=171.5, Z=-1.344, p=.179) taking sex as factor. Spearman's rank test revealed a weak association between the presence of symptoms and placement duration (r=0.296, p=.014) but, marginally, no association with placement errors (r=0.233, p=.056). No significant correlations between scores of the depression rating (DBI) with placement duration (r=0.238, p=.050) and placement errors (r=0.085, p=.489) were revealed, either. However, a weak association between the interaction of aging*symptom intensity with placement duration (r=0.260, p=.033) was observed, while no associations with placement error (r=0.082, p=.506) were shown.

Withdrawal of pegs

The Mann-Whitney U-test also revealed that depressed older adults present a higher withdrawal time (MWU=244.5, Z=-4.099, p=.000) (Figure 3A) and withdrawal errors (MWU=426.5, Z=-2.904, p=0.004) (Figure 3B) than their non-depressed counterparts. The Mann-Whitney U-test analysis revealed no differences between males and females with and without depressive symptoms regarding the duration of peg withdrawal (MWU=157, Z=-1.584, p=.113) and withdrawal error (MWU=200, Z=-1.237, p=.216). Correlation analysis revealed a weak association between the presence of depression symptoms and peg withdrawal duration (r=0.472, p=.000) and with withdrawal errors (r=0.320, p=.008). However, a moderate association between withdrawal duration and symptom intensity (r=0.527, p=.000) (Figure 3C) was revealed, as well as with the interaction of aging*symptom intensity (r=0.531, p=.000). Regarding withdrawal errors, Spearman's rank test revealed a very weak association with symptom intensity (r=0.242, p=.047) (Figure 3C) and a weak association with the interaction of symptom intensity*aging (r=0.441, p=.000).

Figure 3. Mean (± SD) values of peg placement/withdrawal duration (a), errors (b) and a representation of the rate of change between peg withdrawal duration/errors and depression intensity (BDI score) of depressed and nond



Discussion

The goal of this study was to (a) distinguish motor control between older adults with and without depressive symptoms based on different motor requirements (placement/withdrawal of pegs) and (b) estimate the association between the presence of depressive symptoms, depression intensity, and interaction effects between aging and depression intensity, with motor control. In sum, our results showed that depressed older adults present a general worse performance than their nondepressed peers and the depressive symptoms were correlated with motor control, although its intensity and the interaction between aging and depression intensity were correlated circumstantially. This means that depression can impair both motor control requirements, although its intensity as the interaction between aging and depression intensity is related with motor control contextually. Although we didn't have enough samples to verify if the classification of the symptoms of BDI can distinguish motor performance of depressed older adults, the correlations, in turn, revealed that the intensity of the symptoms, such as the interaction between symptom intensity and aging, are strongly associated with a greater slowness on withdrawal of pegs performance.

The GPT, originally, involves the analysis of the placement of small shaped key-pegs which must be oriented correctly to fit in a hole with a random orientation. Assessing the withdrawal of these pegs, Bryden and Roy[45] suggested that we can discriminate measures of visuomotor amplitude (placement) to a simple measurement of motor speed (withdrawal). However, since GPT measures how quickly the 25 pegs are placed and withdrawn, it could be argued that these tasks, in fact, cover a *hybrid control phase*, which consist of both *initial impulse* and *current control* phases, although the *current control* is more robust in the placement task as it demands more accuracy from the participant[28].

Withdrawal of pins from the instrument holes, therefore, can be interpreted as the performance of a movement in a ballistic form to the vicinity of a target that involves mainly a pre-programmed phase without sufficient feedback processing, while the placement of pegs into the holes incorporates higher visual and proprioceptive information of the limb and the target reference point. In this manner, the GPT enables the comparison between the execution of two similar motor tasks with different motor requirements; or more precisely, the distinction between a higher feedback processing versus an effortless planning process, and their respective brain associations.

Since the withdrawal task mainly involves a planning process, these associations can be explained by the observed depression consequences to the frontal lobe functioning[46-48]. Specifically, studies have demonstrated that damage to the inferior parietal lobe, frontal lobes, or basal ganglia hamper the performance of tasks that require more of a planning process[32,49]. Furthermore, previous findings have also demonstrated that individuals with depressive symptoms increase the activation of frontostriatal circuitry as an attempt to compensate cognitive failures[50]. These observations lead us to hypothesize that a low involvement of the frontal lobe (e.g. working memory) on the placement task might be responsible for the absence of significant associations. Furthermore, the detrimental effects to the performance of tasks that require, predominantly, a current control phase have been usually associated with damage on the superior parietal lobe or cerebellum[32,49]. In this manner, we can infer that depression symptoms exert a broad effect upon motor control, although their intensity as the interaction between aging*depression intensity are only associated with motor acts that presents higher frontal lobe requirements.

Apparently, our results and hypothesis corroborate with the findings of Pier, Pier, Hulstijn and Sabbe[51] who observed significant associations between symptom intensity and motor control only in the task that involved, mostly, pre-programmed components of motor planning ($r=0.28$, $p=0.046$) and with the highest complexity task that was guided, essentially, by feedback control ($r=0.41$, $p=0.005$). Although these associations were made with a different clinical scale, BDI correlations on this study presented similar results, revealing positive associations between different performance measures (initiation time: $r=0.31$, $p=0.032$; movement time: $r=0.34$, $p=0.020$, and re-inspection time: $r=0.32$, $p=0.027$) with symptom intensity exclusively in the most complex task that involved, predominantly, a current control phase. Following the hypothesis raised by our study, the lack of association between motor control and symptom intensity (BDI score) revealed in the ballistic task in their study can be explained by the absence of the aging and depression interaction effects, while the higher association in the most complex task can be justified by high complexity implied by the number of segments to be copied, and thus, the increased participation of working memory.

Despite the evident biomechanical differences between men and women, such as the size of their fingers relative to the size of pegs, this study didn't reveal sex-dependent effect between depressed and nondepressed elderlies. Surprisingly, the results of this study contrast with those of Briden and Roy[45] who revealed performance differences between the sexes during removal/placement of pegs. However, some confounding variables such as menopause status and menstrual cycle phase that can promote changes in woman physiology and further influence motor control response of elderly women was not controlled in our study. Therefore, the sex differences analysis of our study might be somewhat flawed and could justify the lack of significant results. It might also be an interesting avenue for further investigations.

In conclusion, our study provides the first evidence of a motor control-dependent effect on the interaction between depression symptoms and aging. The results herein strengthen the need to take careful considerations in defining the requirements of a task into the assessment of motor control of depressed individuals as there are indirect evidences that frontal lobe dysfunctions present a considerable association with the interaction between aging*depression intensity as well with depression intensity itself. Furthermore, ours findings may have clinical implications since the determination of mechanisms that leads to disability in aging are extremely important for the elaboration of preventive measures to help maintain their functional capability[52,53]. It adds evidence to support the claim that the progression of depressive symptoms deserves a closer look when the disorder is established.

Conclusion

The present findings revealed that depressive symptoms can impair the motor control of elderlies and revealed contextual associations between aging and illness intensity with motor performance. The discrimination of motor control aspects raised by this study provides a valuable contribution to the underlying neurophysiology of the interaction between aging and depression symptoms, suggesting the existence of a relevant association between frontal lobe dysfunction and motor control impairments. These indirect measures of cerebral dysfunction can also offer a new path to more rational approaches aimed at assessing and elaborating of preventive measures for depressed elderlies.

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