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O FOCO DE ATENÇÃO NÃO INFLUENCIA O DESEMPENHO DA TAREFA DE PASSAR DE SENTADO PARA DE PÉ EM ADULTOS JOVENS E IDOSOS

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Trabalho de Conclusão de Curso apresentado ao Curso de Fisioterapia da Universidade Federal de Minas Gerais como requisito parcial para o grau de bacharel em Fisioterapia.

Área de Concentração: Desempenho Funcional Humano.

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PREFÁCIO

O texto a seguir foi elaborado em Formato Opcional, semelhante ao utilizado na pós graduação (como descrito na Resolução nº 004/2018 (03 de abril de 2018) do Colegiado de Pós-Graduação em Ciências da Reabilitação da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais), conforme orientações dadas pelo Colegiado de Graduação em Fisioterapia para a apresentação deste trabalho.

Logo após o resumo e o abstract, o tema do trabalho é introduzido com uma revisão da literatura. Espera-se que o leitor compreenda a importância da transferência de sentado para de pé para a independência funcional do indivíduo, e compreenda como o desempenho desta tarefa é afetado pelo envelhecimento. Em seguida são apresentadas as motivações para o desenvolvimento deste estudo por meio da estratégia do direcionamento do foco de atenção durante a execução dos movimento e sua possível contribuição para intervenções clínicas.

Após a introdução, o artigo publicado em decorrência deste trabalho é apresentado de acordo com as normas da ABNT e em seguida, as considerações finais e as referências.

Por fim, no apêndice deste trabalho está a íntegra do artigo, de acordo com as normas do periódico ñJournal of Motor Behaviorò no qual foi publicado em fevereiro de 2020.

O projeto de pesquisa foi aprovado pelo comitê de ética, número de registro CAAE 27290514.9.0000.5149.

RESUMO

Um foco externo de atenção pode melhorar o desempenho motor, mas há poucas pesquisas sobre seus efeitos para os idosos em tarefas de mobilidade do dia a dia. Neste estudo 57 idosos e 59 adultos jovens realizaram o sentar-para-levantar e levantar-sentar-se segurando uma xícara, em três níveis de dificuldade (copo vazio ou cheio, em velocidade normal ou rápida). Metade foi instruída a direcionar a atenção internamente (em seus movimentos) e a outra metade externamente (na xícara). Os efeitos de foco, idade e nível de dificuldade foram testados para tempo de movimento, inclinação média da xícara, variabilidade da inclinação e suavidade com ANOVAs. 2 x 2 x 3. Efeitos significativos de dificuldade foram consistentes entre as variáveis ($p < 0,05$). Um efeito de foco esteve presente apenas para a variabilidade da inclinação durante o tarefa de assentar ($p < 0,03$), favorecendo um foco interno (menor variabilidade). A interação entre foco e idade foi significativa para a inclinação média do copo, mas os testes post hoc não revelaram quaisquer diferenças significativas. Os resultados deste estudo, em conjunto com a literatura, sugerem que um foco externo pode não beneficiar o desempenho de adultos jovens ou mais velhos nas atividades de mobilidade geral da vida diária. A suposição predominante de que um foco externo é sempre benéfico para o desempenho precisa de mais testes empíricos.

Palavras-Chave: Foco de atenção. Idoso. Mobilidade.

ABSTRACT

An external focus of attention can improve performance, but there is little research on effects for the elderly in everyday, well-learned mobility tasks. 57 older and 59 young adults performed the sit-to-stand and stand-to-sit while holding a cup, at three difficulty levels (cup empty or full, at normal or fast speed). Half were instructed to focus internally (on their movements) and half externally (on the cup). The effects of focus, age, and difficulty level were tested for movement time, mean inclination of the cup, inclination variability, and smoothness with 2 2 3 ANOVAs. Significant effects of difficulty were consistent across variables ($p < 0.05$). An effect of focus was present only for the inclination variability of the stand-to-sit ($p < 0.03$), favoring an internal focus (less variability). The age focus interaction was significant for mean cup inclination, but post hoc tests failed to reveal any significant differences. The results of this study, together with the literature, suggest that an external focus may not benefit the performance of young or older adults in general mobility activities of daily living. The prevalent assumption that an external focus is always beneficial for performance needs further empirical testing.

Keywords: Elderly. Focus of attention. Mobility.

INTRODUÇÃO

A tarefa de transferência da posição sentada para a posição de pé é fundamental para a execução das atividades cotidianas. Passar de sentado para de pé impõe significativas demandas de força muscular, equilíbrio e coordenação dos diversos segmentos corporais à medida que o centro de massa corporal se desloca. Além disso, essa tarefa é frequentemente realizada no dia a dia em associação com outras que impõem desafios adicionais de controle. Um exemplo de tarefa associada ao passar da posição sentada para de pé é segurar uma xícara com líquido (CANNING *et al.*, 2003; LUNDIN-OLSSON; NYBERG; GUSTAFSON, 1998; MUHAIDAT *et al.*, 2014). Além dos requisitos de resistência e equilíbrio corporal, o indivíduo deve controlar cautelosamente a aceleração e a orientação da xícara para evitar derramar seu conteúdo (TOGO; KAGAWA; UNO, 2012).

Para indivíduos idosos, as tarefa de passar de sentado para de pé (st-dp) e de pé para sentado (dp-st) são mais desafiadoras do que para adultos jovens, principalmente devido às reduções progressivas da força muscular e do equilíbrio (HUGHES; MYERS; SCHENKMAN, 1996). Para muitos idosos, a realização da tarefa requer grande esforço, de forma que o desempenho nas transições de st-dp e dp-st se torna indicador de mobilidade funcional Evidências indicam que a redução na suavidade dos movimentos st-dp e dp-st diferencia idosos caidores e não caidores. (DOHENY *et al.*, 2011). Além disso, diferença de tempo entre o teste *Time Up and Go* (que envolve as tarefas de st-dp e dp-st) com e sem associação da tarefa adicional de segurar uma xícara é um indicador válido de fragilidade e risco de quedas em indivíduos idosos (MUHAIDAT *et al.*, 2014; TANG *et al.*, 2015; TOGO; KAGAWA; UNO, 2012).

Desta forma, as tarefas st-dp e dp-st tem grande relevância funcional. Para indivíduos idosos o uso de estratégias que visam a mehorar o desempenho nestas tarefas pode ser de grande utilidade em tratamentos de reabilitação.

Uma estratégia apontada para a melhora do desempenho motor é o direcionamento do foco de atenção. Durante a execução das atividades motoras, o foco de atenção pode ser direcionado para os efeitos do movimento no ambiente (foco externo) ou para o próprio movimento (foco interno). A "hipótese da ação restrita" (WULF; MCNEVIN; SHEA, 2001; WULF; SHEA; PARK, 2001) explica as vantagens do foco externo (FE) de atenção no desempenho motor e na aprendizagem de tarefas. De acordo com hipótese, o foco interno (FI) induz o controle consciente dos movimentos que interfere nos processos automáticos de coordenação e ocasiona um movimento fragmentado. Por outro lado, o FE favorece o controle inconsciente que resulta na automaticidade do movimento, tornando-o mais fluido e suave.

De acordo com "hipótese de ação restrita", a condição de dificuldade da tarefa é determinante para os efeitos de foco de atenção, de modo que os benefícios do efeito de FE são vistos em tarefas mais complexas e desafiadoras que levam o os indivíduos a tentar intervir conscientemente no movimento do corpo com maior frequência (LANDERS *et al.*, 2005; WULF; TÖLLNER; SHEA, 2007). Por isso, a maioria dos estudos sobre os efeitos do foco de atenção se restringe a indivíduos com pouca ou nenhuma experiência realizando tarefas relativamente novas, ou tarefas esportivas (WULF, 2013; WULF; TÖLLNER; SHEA, 2007). Assim ainda existem poucas evidências relacionadas ao efeito do foco de atenção no desempenho de atividades de vida diária, como as transferências st-dp e dp-st.

Em tarefas de mais difícil execução, os idosos tendem a controlar de forma consciente o movimento e, em concordância com a "hipótese de ação restrita", o controle consciente do movimento contribui negativamente para a sua fluidez. Dada a importância fundamental de st-dp e dp-st para a independência, os efeitos positivos das instruções de EF podem gerar aplicações clínicas interessantes em tratamentos de reabilitação para idosos. Para testar estas expectativas, este estudo utilizou como tarefas experimentais o st-dp e dp-st enquanto segura uma xícara.

Desta forma, este estudo investigou os efeitos do foco de atenção no desempenho das tarefas de passar de st-dp e de dp-st segurando uma xícara realizadas em 3 níveis de dificuldade (xícara vazia e velocidade normal; xícara cheia e velocidade normal; xícara cheia e velocidade rápida), entre idosos e jovens.

A hipótese do estudo é que o FE promoverá um melhor desempenho na atividade de st-dp e dp-st, tanto para idosos quanto para jovens, quando comparado o FI. Esse efeito será observado à medida que o nível de dificuldade da tarefa aumenta.

Esta investigação resultou na publicação do artigo ñAttention Focus Does Not Influence Performance of Sit-to-Stand in Young and Older Adultsò em fevereiro de 2020 na revista ñJournal of Motor Behaviorò. O artigo está disponível na íntegra por meio do link https://doi.org/10.1080/00222895.2020.1723477 e no apêndice deste trabalho. O texto do artigo foi transcrito a seguir.

ARTIGO

Attention Focus Does Not Influence Performance of Sit-to-Stand in Young and Older Adults

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ABSTRACT

An external focus of attention can improve performance, but there is little research on effects for the elderly in everyday, well-learned mobility tasks. 57 older and 59 young adults performed the sit-to-stand and stand-to-sit while holding a cup, at three difficulty levels (cup empty or full, at normal or fast speed). Half were instructed to focus internally (on their movements) and half externally (on the cup). The effects of focus, age, and difficulty level were tested for movement time, mean inclination of the cup, inclination variability, and smoothness with 2 2 3 ANOVAs. Significant effects of difficulty were consistent across variables ($p < 0.05$). An effect of focus was present only for the inclination variability of the stand-to-sit ($p < 0.03$), favoring an internal focus (less variability). The age focus interaction was significant for mean cup inclination, but post hoc tests failed to reveal any significant differences. The results of this study, together with the literature, suggest that an external focus may not benefit the performance of young or older adults in general mobility activities of daily living. The prevalent assumption that an external focus is always beneficial for performance needs further empirical testing.

Keywords: Elderly, focus of attention, mobility.

INTRODUCTION

Attention can improve motor performance (Wulf, Shea, & Lewthwaite, 2010). Attention can be directed to the effects of movement on the environment (external focus, EF) or to movement itself (internal focus, IF). Extensive literature indicates that an EF produces better performance and learning on a variety of tasks (for a review, see Wulf, 2013). Benefits of an external over an IF of attention are seen in movement efficiency (e.g., muscular activity, force production, cardiovascular responses, etc). In particular, increased muscle fiber recruitment, increased force production, and more effective movement coordination under an EF can potentially increase movement speed (Fasoli, Trombly, Tickle-Degnen, & Verfaellie, 2002; Porter, Nolan, Ostrowski, & Wulf, 2010; Totsika & Wulf, 2003). Positive effects are also observed for movement effectiveness (e.g., accuracy, stability, etc., Wulf, 2013). The reason, according to the ñconstrained action hypothesisò (Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001), is that an IF may induce conscious control that interferes with automatic coordination, causing performance to suffer. An EF, on the contrary, would favor unconscious, fast and reflexive processes, resulting in greater movement fluidity.

According to the ñconstrained action hypothesis,ò the beneficial effects of an EF are especially salient in difficult tasks, when individuals would attempt to consciously intervene in body movement more frequently (Landers, Wulf, Wallmann, & Guadagnoli, 2005; Wulf, Tollner, & Shea, 2007). Therefore, to guarantee sufficiently challenging tasks, most research has focused on inexperienced individuals performing novel sports-related tasks (Wulf, 2007, 2013), while the activities of daily living have received less attention. Would an EF improve the performance of well-learned activities of daily living, such as sit-to-stand and stand-to-sit?

The sit-to-stand and stand-to-sit are fundamental for independence and become more difficult with age. Sit-to-stand and stand-to-sit require greater hip joint moments than stair climbing or walking (Rodosky, Andriacchi, & Andersson, 1989). Additionally, good control of balance is required to deal with the rapid shift of body mass between the seat and the feet (Riley, Schenkman, Mann, &

Hodge, 1991). With age-related decreases in muscle strength and balance control, the sit-to-stand and stand-to-sit become more difficult, and many older adults perform the task close to their maximal abilities (Hughes, Myers, & Schenkman, 1996). Deterioration of sit-to-stand and stand-to-sit performance in older adults is a key indicator of decreased mobility and increased risk of falls (Buatois et al., 2008).

Very frequently, the sit-to-stand and stand-to-sit are performed in association with manual tasks that pose additional control challenges, such as holding a cup full of liquid (Muhaidat, Kerr, Evans, Pilling, & Skelton, 2014). For example, one may be sitting at a table in a cafe, stand up and walk away with a coffee cup. Acceleration and orientation of the cup must be controlled to avoid spilling (Togo, Kagawa, & Uno, 2012) and movement time may increase to accommodate precise stabilization of the cup. The time difference between the Timed Up and Go test (which involves Si-St and StSi) with and without holding a cup appears to be a valid marker of frailty and fall risk (Muhaidat et al., 2014; Tang, Yang, Peng, & Chen, 2015; Togo et al., 2012). From an experimental point of view, holding a cup also makes for a useful experimental model because it creates a natural external referent to which attention may or may not be directed during sit-to-stand and stand-to-sit, depending on instructions. Previous studies have shown that an EF on a supra-postural task goal increases movement effectiveness (McNevin & Wulf, 2002; Wulf, Mercer, McNevin, & Guadagnoli, 2004; Wulf, Weigelt, Poulter, & McNevin, 2003).

It is possible that a simple behavioral intervention with EF instructions during sit-to-stand and stand-to-sit would be especially beneficial for the elderly. Older adults are presumably more inclined to consciously control their movements in challenging tasks (Woollacott & ShumwayCook, 2002). If the ñconstrained action hypothesisò is correct, conscious attention to body movement (IF) impairs automaticity and fluidity of movement. EF instructions, in contrast, may increase movement fluency, regularity, and speed (Kal, Van Der Kamp, & Houdijk, 2013). Given the fundamental importance of sit-to-stand and stand-to-sit for independence, positive effects of EF instructions could generate interesting clinical applications in rehabilitation treatments for the elderly.

This study, therefore, investigated whether attention focus instruction can have any impact on the well learned daily life activity of sit-to-stand and stand-to-sit holding a cup, for young and older adults, in three different task difficulty levels. We hypothesized that focus instructions would interact with age and difficulty level, being especially beneficial in more difficult conditions and for older people, at the level of movement outcome. We expected that EF instructions would produce greater movement efficiency, that is, shorter movement times. We also expected EF instructions would produce greater movement effectiveness with respect to the overall goal of keeping the cup vertical and stable during the transfer to avoid spilling. More specifically, we expected that for older people in the most difficult condition, the EF would lead to faster sit-to-stand and stand-to-sit transitions, and to cup trajectories with less inclination (more accuracy), and increased smoothness and less variability (more stability).

METHOD

Participants

The inclusion criteria for this study were: (1) age between 18 and 40 years or over 60; (2) no musculoskeletal symptoms affecting sit-to-stand and stand-to-sit; (3) no cognitive disorder affecting the ability to follow instructions. Participants that felt pain or discomfort during the task (2 older adults) or who were unwilling to complete it (1 young and 4 older adults) were excluded. A total of 59 healthy young adults (44 females) and 57 healthy older adults (41 females) signed consent for participation (approved by the Institution's Ethics Committee) and completed the study.

Task and Apparatus

Participants stood up and sat down from a chair (0.47 m high) holding and transferring a cup (with a smartphone attached) between two surfaces of different heights (0.79 and 1.07 m) Figure 1). A Motorola smartphone (Android XT1058) with Sensor Kinetics Pro (Innoventions, Inc.) with a magnetometer, a gyroscope, and linear acceleration sensors was used to record the data.

Procedures

Data collection of daily life tasks in ecologically valid situations has been greatly facilitated by the development of valid and reliable smartphone technology (Boonstra et al., 2006; Galan-Mercant, Baron-Lopez, LabajosManzanares, & Cuesta-Vargas, 2014; Nishiguchi et al., 2012). We used an android-based application and sensors after comparison with data from an optoelectronic system (10 cameras, Oqus Qualisys, Sweden), a gold standard for kinematic analysis. Four retro-reflective markers were placed on the smartphone. One participant performed five repetitions of the task in each of three different task difficulty levels. We expected that dependent measures averaged over five repetitions would be representative of typical performance in each experimental condition. Angle time series collected simultaneously from the two systems were compared. Figure 2 shows an example of a cup angle series from the two systems in a sit-to-stand movement. The relative difference between the two series, averaged over time, with the Qualisys as a reference, varied from 0.26 to 0.29%. These tests indicated the validity of sensor data.

In line with a clinical trial rationale, participants were assigned to one of two intervention groups in counterbalanced order, as they enrolled for the study: EF instructions (29 young and 27 older adults) or IF instructions (30 young and 30 older adults). All participants sat on a chair (Figure 1) and were instructed to grab the cup with their non-dominant hand (according to self-reported handedness) and transfer it from the lower to the higher surface as they rose from the chair, or transfer it from the higher to the lower surface as they sat down, always looking straight ahead. The EF group was instructed to ñthink all the time about the cup and the liquid inside the cup.ò The IF group was instructed to ñthink about your own arm and the coordination of your movementsò.

Participants performed three blocks of five trials each, under three difficulty levels: (1) empty cup at normal speed (EN); (2) full cup at normal speed (FN); and (3) full cup at a fast speed (FF). Normal and fast speed were self-chosen for each participant. For normal speed, participants were told to perform the task as they usually do in daily life. For fast speed, they were told to perform the task as fast as they could without spilling liquid. Colored adhesive tape was used to mark and maintain a standard level of liquid in the cup (1 cm below the rim). In case of spilling, the trial was discarded, the liquid was refilled to the mark and the participant was asked to repeat the trial. Focus instructions were reinforced before each condition.

Participants then answered three questions: *(1) what did you focus on while performing the task?; (2) were you able to follow the instruction of attention focus?; and (3) on a scale of 0 to 10, how well did you follow the instruction?*

Data Reduction

Given the requirements of smartphonesôoperating systems, the main issue with their inertial sensors is the variability of acquisition rate (30ï 90 Hz). After spectral density analysis showed no relevant power above 10 Hz, linear interpolation was used to achieve a fixed common sampling frequency of 30 Hz for all three sensors. Data was then filtered with a low pass Butterworth filter of order 3 and cutoff frequency of 10 Hz. An automated Matlab (MathWorks Inc.) routine aided by visual analysis of the accelerometer time series determined timestamps for the start and end of each sit-to-stand and stand-to-sit. Movement time was defined in seconds.

The angle (radians) of the cup with respect to the global vertical was calculated. The magnetometer was used to mark a three-dimensional vector whose variation from an initial position is taken as an inclination (the cup and smartphone were vertical while resting on a table before beginning and after the end of the movement). The inclination was then projected to the vertical axis to calculate the smartphone angle (parallel to the cup). Magnetometer signals are noisy so data from the other sensors are used to improve it. The magnetometer signal is interpolated to optimally reduce the error of its derivatives compared to the gyroscope and accelerometer. The resulting signal is an estimate of the cup angle. The average and standard deviation of the cup angle over time, for the duration of a sit-to-stand and stand-to-sit, were obtained for each trial.

Smoothness is a measure of the shape of a movement time series. While jerky and irregular movements have low smoothness, steady, regular, and fluent movements are smoother. Smoothness was calculated with the negative spectral arc-length measure, as defined by Balasubramanian, Melendez-Calderon, and Burdet (2012). For each cup angle speed profile v(t), t 2 [0, T] and duration T, we generated its Fourier magnitude spectrum. Then negative of the arc length is calculated as

$$\eta_{sal} \triangleq -\int_0^{\omega_c} \sqrt{\left(\frac{1}{\omega_c}\right)^2 + \left(\frac{d\hat{V}(\omega)}{d\omega}\right)^2} d\omega$$

$$\hat{V}(\omega) \triangleq \frac{V(\omega)}{V(0)}$$

where V(x) is the Fourier magnitude spectrum of v(t), and [0, xc] is the frequency band occupied by the cup movement. Greater values of this measure indicate smoother movements.

Statistical Analysis

Means and standard deviations (mean ± SD) were used as descriptive statistics. Participantsômean age was compared between IF and EF groups with independent samples t-tests. A chi-square test was used to compare the frequency of males and females between IF and EF groups. The two-proportion z test was used to test whether the frequency of discarded trials (due to spilling) was different between IF and EF groups. Adherence to instructions was compared across groups with Fisherôs exact tests for categorical answers (question 2) and a 2 (age) x 2 (focus) ANOVA for score-based answers (question 3). Sit-to-stand and stand-to-sit performance variables were analyzed separately. The dependent variables of interest were the average and standard deviation of cup angle over time, smoothness and movement time. Data were analyzed with a 2 (Age) x 2 (Focus) x 3 (Difficulty level) analysis of variance (ANOVA), with repeated measures on the last factor. All statistics were calculated using the Statistical Package for the Social Sciences Version 21.0 (SPSS for Windows, Chicago, IL). Statistical significance was set at $p < 0.05$.

RESULTS

Participant Characteristics in the Two Attention Instruction Groups

A total of 116 participants (57 right-handed in IF and 50 right-handed in EF, 3 left-handed in IF and 6 lefthanded in EF) took part in this study. The frequency of females and males was not statistically different (p = 0.823) among young participants in the IF (22 females, 8 males) compared to the EF (22 females, 7 males) group, or among old participants (p = 0.152) in the IF (24 females, 6 males) compared to the EF (17 females, 10 males) group. Mean age also did not differ (p = 0.199) between young participants in IF (24.90 ± 3.26) and EF (23.72 ± 3.68) groups (overall mean: 24.32 ± 3.50) or old participants (p = 0.532) in IF (68.37 ± 5.60) and EF (69.37 ± 6.46) groups (overall mean: 68.84 ± 5.99).

Ability to Follow Instructions

For the question **ñ***were you able to follow the instruction of attention focus?***ò** the proportion of **ñ***Yes***ò** responses among old participants for EF (96.3%) and IF (89.7%) were not statistically different (p = 0.612). The proportion of **ñ***Yes***ò** responses among young participants for EF (96.6%) and IF (100%) were also not statistically different (p = 0.491).

For the question **ñ***on a scale of 0 to 10, how well did you follow the instruction?***ò** the average scores for the older adults under EF and IF instructions were respectively, 8.61 ± 1.09 and 8.62 ± 1.30. The average scores for the young adults under EF and IF instructions were respectively, 8.41 ± 0.92 and 8.05 ± 1.10. Age, Focus, and the Age x Focus interaction were not significant (p > 0.063).

The content of answers to **ñ***what did you focus on while performing the task?***ò** revealed, however, that many individuals had difficulty to focus on actual internal content. A total of 8 of the 30 older adults (26.6%) and 13 of the 30 young adults (43.3%) in the IF group gave answers indicating content inappropriate to received instruction. For example, some participants answered that they had ñfocused on not spilling,ò or ñon looking straight ahead instead of looking at the cup.ò In contrast, 2 of the 27 older adults (7.40%) and 2 of the 29 young adults (6.89%) in the EF group gave answers indicating content inappropriate to received instruction.

Thus, we ran statistical ANOVAs of the effects of EF and IF on performance only for the 91 participants whose answers ensured they had used attention content that was appropriate to their respective instructions. Table 1 shows all ANOVA p values.

Performance (Movement Outcome Measures)

Table 1 shows that the main effect of Difficulty was significant for all variables. The effects of Difficulty were clear in movement time, which was significantly different (F_(2,174) = 62.616, p = 0.001, partial ɖ2= 0.419 for sit-to-stand and F_(2,174) = 52.518, p = 0.001, partial ɖ2= 0.376 for stand-to-sit) between the three difficulty levels: empty cup at normal speed (3.707 ± 0.113 for sitto-stand and 4.046 ± 0.121 for stand-to-sit); full cup at normal speed (4.545 ± 0.129 for sit-to-stand and 4.913 ± 0.150 for stand-to-sit); and full cup at a fast speed (3.778 ± 0.103 for sit-to-stand and 4.002 ± 0.123 for stand-to-sit).

However, there were no significant differences in movement time (F_(2,174) = 0.106, p = 0.746, partial ɖ2= 0.001 for sit-to-stand and F_(2,174)= 0.226, p = 0.636, partial ɖ2= 0.003 for stand-to-sit) between the IF (4.044 ± 0.160 for sit-to-stand and 4.377 ± 0.180 for stand-to-sit) and EF groups (3.976 ± 0.137 for sit-to-stand and 4.264 ± 0.154 for stand-to-sit). No significant interaction effects involving Focus were significant (p Ó0.220).

Movement time also did not differ significantly (F_(2,174) = 0.210, p = 0.648, partial ɖ2= 0.002 for sit-to-stand and F_(2,174) = 0.073, p = 0.788, partial ɖ2= 0.001 for stand-to-sit) between young participants (3.962 ± 0.153 for sit-to-stand, 4.352 ± 0.172 for stand-to-sit) and old participants (4.058 ± 0.145 for sit-to-stand, 4.288 ± 0.163 for stand-to-sit). There were significant Difficulty Age interaction effects for movement time (F_(2,174) = 3.284, p = 0.040, partial ɖ2= 0.036 for sit-to-stand and F_(2,174) = 2.974, p = 0.054, partial ɖ2= 0.033 for stand-to-sit), suggesting that difficulty may affect movement time for young and old participants differently. Given that the main effect of difficulty was quite consistent across variables, and that the focus of our analysis was on Focus, but not Difficulty or Age effects, these interactions were not further investigated.

A significant main effect of Focus was present only for inclination variability of the stand-to-sit, (F_(1,87) = 10.131, p = 0.002, partial ɖ2= 0.104). The group average values (IF: 0.049 ± 0.003; EF: 0.063 ± 0.003) indicate that variability of angle was significantly higher for EF compared to IF (Figure 3).

An Age Focus interaction effect was significant only for the average inclination angle during the sit-to-stand (F_(1,87) = 4.266, p = 0.042, partial ɖ2= 0.047 for sit-to-stand and F_(1,87)= 4.945, p = 0.029, partial ɖ2= 0.054 for stand-to-sit). However, Bonferroni-corrected post hoc independent t tests showed no differences for sit-to-stand for the young participants (p = 0.267) between IF (0.141 ± 0.064) and EF (0.176 ± 0.116), or for old participants (p = 0.127) between IF (0.207 ± 0.135) and EF (0.158 ± 0.063). Results were similarly not significant in the stand-to-sit for young participants (p = 0.121) between IF (0.139 ± 0.060) and EF (0.190 ± 0.122), or for old participants (p = 0.177) between IF (0.208 ± 0.147) and EF (0.160 ± 0.073). These results are shown in Figure 4. No other interactions involving Focus were significant.

The frequency of discarded trials (due to spilling) did not differ (p = 0.144) between the groups receiving IF (12 out of 900 trials) or EF instructions (19 out of 840 trials).

DISCUSSION

The effects of attention focus on activities of daily living are rarely investigated. Adequate sit-to-stand and stand-to-sit performances are fundamental for maintaining independence in old age. Positive effects of focus instructions could be used in rehabilitation applications to improve the performance of this task. Thus, our trial investigated whether focus instruction interventions had any impact on performance (at the level of movement outcome) of the well-learned activity of sit-to-stand and stand-to-sit while holding a cup, for young and older adults, at three difficulty levels. We hypothesized that in the most difficult condition, for older people, an EF would lead to greater movement

effectiveness, that is, less cup inclination, lower variability, and increased smoothness. The results did not support our hypothesis.

We failed to find significant focus effects except for worse angle stability under EF compared to IF for the stand-to-sit. However, this effect was not consistent, as all other performance variables showed null focus effects. Our null results are surprising in view of the conclusion of a literature review indicating that the enhancements in motor performance with an EF compared to IF are well established. The review author states: ñThe breadth of this effect is reflected in its generalizability to different skills, levels of expertise, and populations é ò (Wulf, 2013, p. 99). Our results are inconsistent with this claim. In our study, an EF did not enhance the motor performance of sit-to-stand and stand-to-sit while holding a cup, a skill that involves body transfer and object manipulation (Gentile, 2000), regardless of difficulty level and population. What factors may explain these null results?

First, we need to point out that we controlled for adherence to instructions. Self-reported adherence scores were similar across conditions and groups. However, several individuals (21%) reported focusing on content inconsistent with the instructions they had received. Our analysis included only individuals with appropriate attention content. Therefore the lack of focus effects cannot be attributed to inadequate adherence to instruction.

Second, our results are consistent with many recent studies involving day-to-day posture and mobility skills. Despite some previous research showing benefits of an EF for these kinds of skills (Chiviacowsky, Wulf, & Wally, 2010; McNevin, Weir, & Quinn, 2013; Richer, Saunders, Polskaia, & Lajoie, 2017), several studies report null effects for focus instructions for posture and mobility skills (De Bruin, Swanenburg, Betschon, & Murer, 2009; Landers, Hatlevig, Davis, Richards, & Rosenlof, 2016; Mak, Young, Chan, & Wong, 2018; Melker Worms et al., 2017; Richer, Polskaia, & Lajoie, 2017; Yogev-Seligmann, Sprecher, & Kodesh, 2017).

Richer, Polskaia, and Lajoie (2017) found no difference between IF and EF for control of quiet stance in older adults. For gait performance, no effects on walking stability or balance recovery after gait perturbations were found for older adults (Melker Worms et al., 2017). Yogev-Seligmann et al. (2017) reported that gait variability could not be improved by focusing on keeping steps consistent or focusing on pacing gait to the rhythm of a metronome. Both focus instructions actually increased the variability of some spatiotemporal gait parameters. Mak et al. (2018) found that although IF appears to compromise gait stability, EF instructions did not improve gait stability compared to a control condition in older adults. Benefits of an EF were again not found in a randomized controlled trial on the learning of balance skills for the healthy elderly (De Bruin et al., 2009) or patients with Parkinson's Disease (Landers et al., 2016). No studies examining the effects of attention focus on the performance of the sit-to-stand and stand-to-sit were found. Our study appears to be the first on the topic, and our results are consistent with many experiments involving activities of daily living.

In the attention focus literature, the lack of benefits of EF instructions has been attributed to different factors. Researchers have argued that the benefits of an EF do not apply to movement tasks (i) that do not involve implements and have no clearly intended environmental effect (Melker Worms et al., 2017); (ii) that are too easy (Landers et al., 2016; Wulf, 2008); or (iii) that were learned in early childhood without declarative knowledge (Melker Worms et al., 2017). We will argue below that the first two reasons are not pertinent to our study, with the third reason being the most probable explanation for our results.

The first argument is that the benefits of an EF would not apply to movement tasks that do not involve action on specific objects. Usually, during sit-to-stand and stand-to-sit, the individual does not intend to produce any specific effects on external objects. In such tasks, an EF may in fact not benefit performance (see, e.g., Lawrence, Gottwald, Hardy, & Khan, 2011). In this study, however, we associated an object-manipulation goal to the sit-to-stand and stand-to-sit. This ensured a natural external reference to which attention could naturally be directed, depending on instructions. Our performance variables specifically reflect effectiveness to control the environmental effects of movement: the cup average angle, its stability, and smoothness. Thus, we expected that the benefits of an EF would apply to the performance of our task, but no advantages of an EF were found. Also, the lack of effects on movement time suggests that sit-to-stand and stand-to-sit, as a whole, were not affected.

Second, the literature indicates that an EF is purportedly more beneficial in difficult tasks, because it would prevent attempts to consciously intervene in body movement (Landers et al., 2005; Wulf, 2008; Wulf et al., 2007). To avoid a lack of effects due to unchallenging conditions, our task had three difficulty levels. Our design is limited in that it did not include a possible intermediate difficulty condition with an empty cup at fast speed. However, performance results show that our difficulty manipulation significantly affected all variables, for both age groups [1].

The sit-to-stand and stand-to-sit with a full cup at the fastest possible speed correspond to the most difficult real-life version of the task. With no EF benefits on movement effectiveness and movement time for this version of the task, effects in any other less challenging, ecologically valid versions are unlikely.

This brings us to the third, most probable explanation for results: possibly, general postural and mobility skills that are acquired spontaneously during normal motor development with little declarative instruction (phylogenetic skills such as the sit-to-stand) are less vulnerable to interferences of attention focus (Melker Worms et al., 2017; Young & Mark Williams, 2015). Specialized complex skills learned later in life (ontogenetic skills such as sports gestures), in contrast, are usually acquired with great amounts of explicit instruction in early practice (Masters & Maxwell, 2008). For these tasks, an IF may revert the individual back to an earlier declarative stage of learning and interfere with the automaticity of control, while an EF might prioritize relevant, goal-related information for fluent coordination (Melker Worms et al., 2017; Young & Mark Williams, 2015). We speculate that because the sit-to-stand is a phylogenetic mobility skill, it would be less prone to the negative effects of an IF or the positive effects of an EF.

Interpretations of this study's results in the context of the available literature for general postural and mobility activities of daily living suggest that an EF of attention may not benefit the performance of healthy young and older adults in well-learned tasks. They indicate that the assumption that an EF is to be always preferred (Wulf, 2013, 2016; Wulf et al., 2007) needs further empirical testing for activities of daily living. This study is limited in that it did not assess coordination but only performance measures at the level of movement outcome. An EF might positively affect the coordination of postural and mobility tasks for example in individuals with neurological health conditions that impair automaticity of movement.

Note

1. Note that the small difference in movement time (0.089s) between EN and FF does not invalidate our classification of difficulty. Participants used similar times in these two conditions because when the cup was full, they had to slow down to avoid spilling. When the cup was empty, they felt comfortable moving faster as there weren't any negative consequences. FF is the hardest and EN is the easiest of the three conditions.

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TABLES

Table 1

TABLE 1. Significance values (*p*) for ANOVAs including participants who reported attention content appropriate to instructions (91).

	Movement time		Inclination average		Inclination variability		Smoothness	
	Sit to Stand	Stand to Sit	Sit to Stand	Stand to Sit	Sit to Stand	Stand to Sit	Sit to Stand	Stand to Sit
Age	0.648	0.788	0.335	0.349	0.951	0.121	0.578	0.578
Focus	0.746	0.636	0.745	0.990	0.224	**0.002**	0.891	0.891
Difficulty	**0.001**	**0.001**	**0.003**	**0.002**	**0.027**	**0.014**	**0.001**	**0.001**
Age*Focus	0.425	0.247	**0.042**	**0.029**	0.632	0.847	0.086	0.086
Difficulty*Age	**0.040**	0.054	0.961	0.943	0.681	0.760	0.809	0.809
Difficulty *Focus	0.705	0.220	0.995	0.979	0.751	0.536	0.632	0.632
Difficulty*Age*Focus	0.334	0.544	0.714	0.788	0.481	0.356	0.941	0.941

Statistically significant values are in bold.

FIGURES

Figure 1: Task setup.

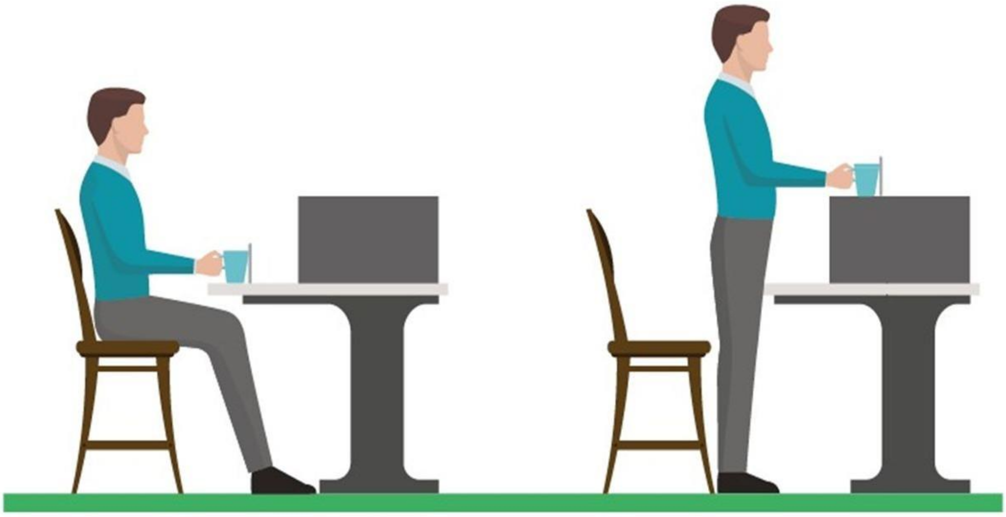


Figure 2: Example of cup angle series from inertial sensors (orange) and from an optoelectronic system (blue) during a sit to stand movement.

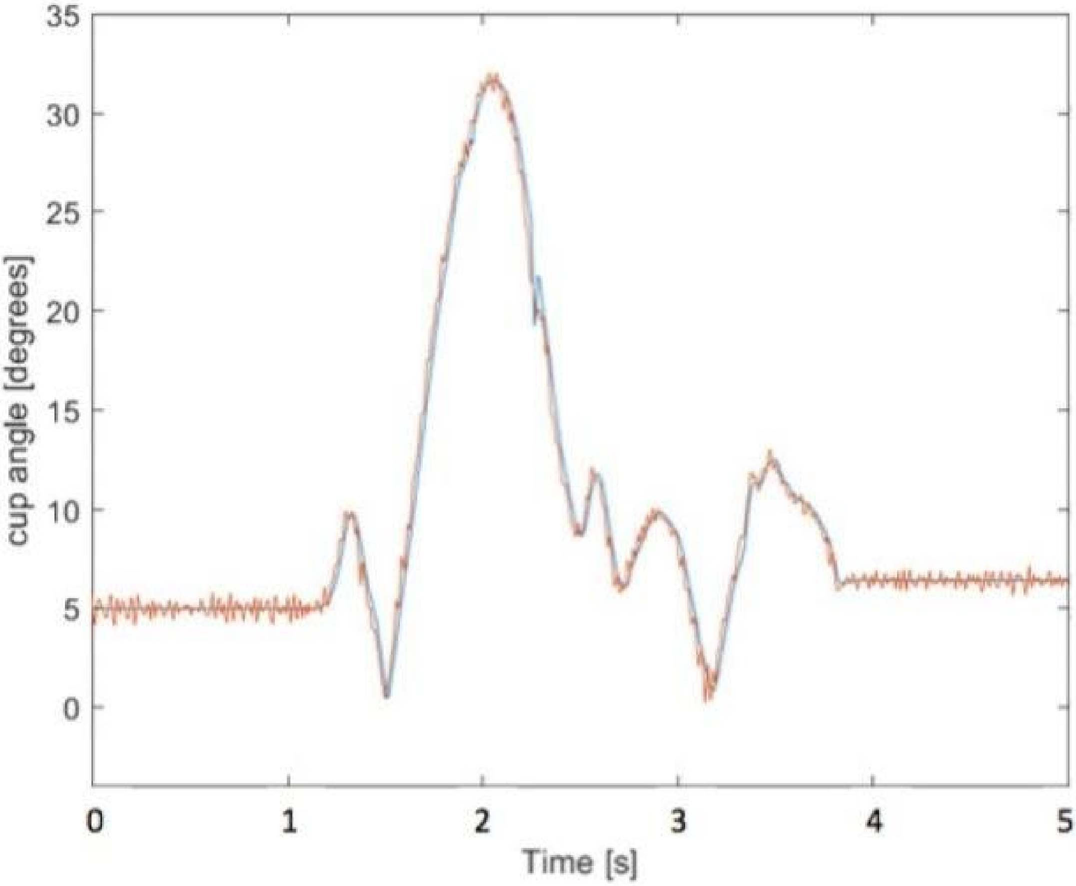


Figure 3: Significant difference in the variability of inclination (standard deviation over time) between focus groups for the stand-to-sit. Error bars indicate ± 2 standard errors.

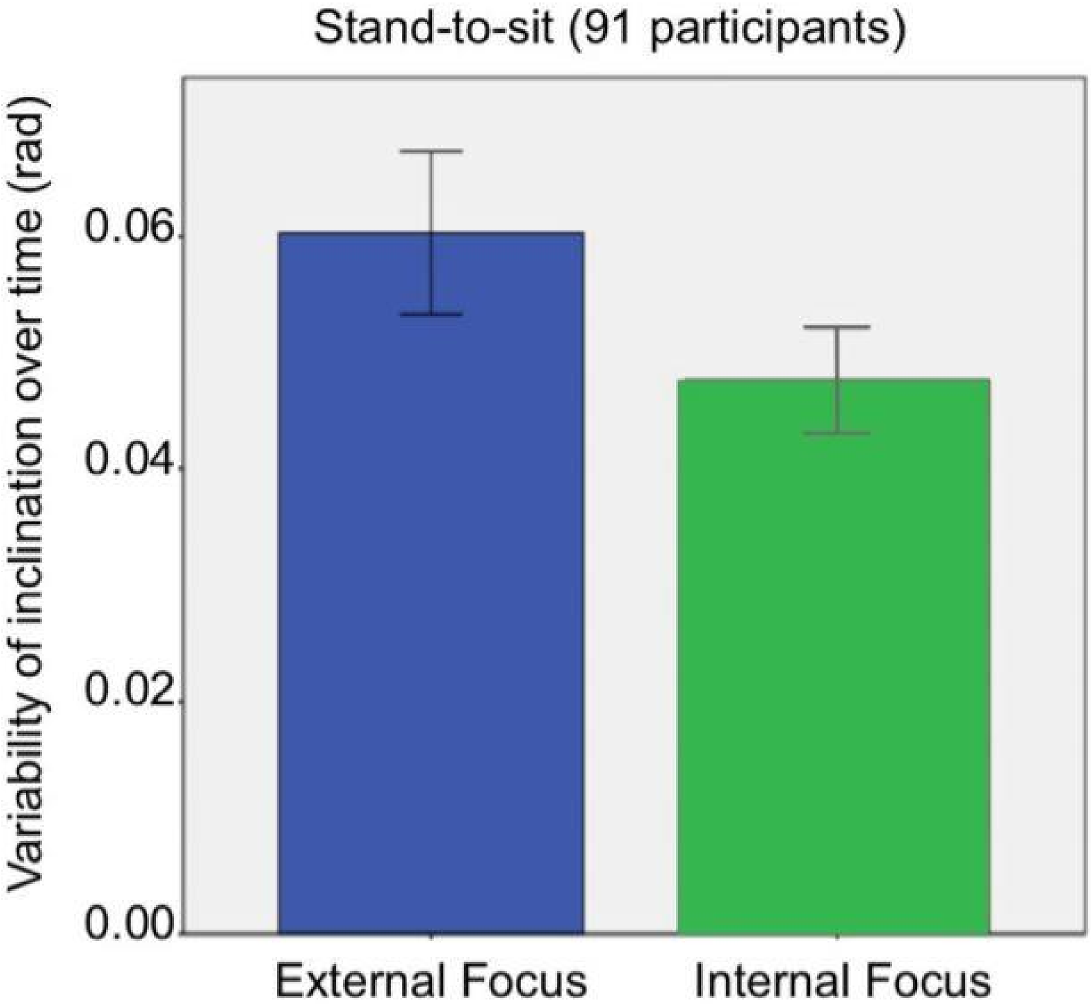
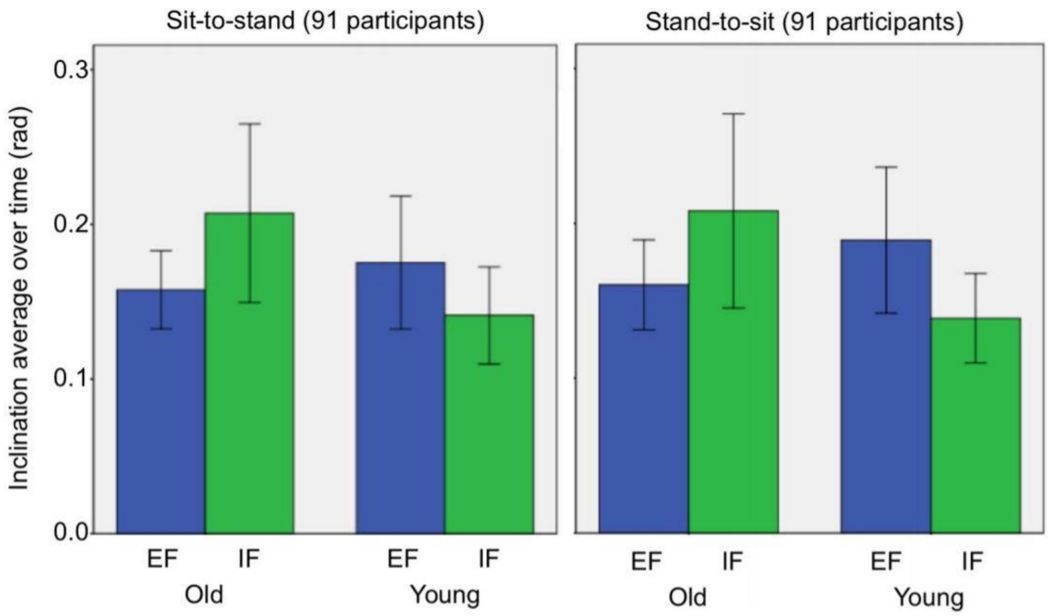


Figure 4: Comparison of inclination average over time for older and younger participants in the external focus (EF) and internal focus (IF) groups. No pairwise comparisons were significant. Error bars indicate ± 2 standard errors.



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CONSIDERAÇÕES FINAIS

O presente estudo teve como propósito contribuir com novas estratégias para a prática clínica, visando a melhoria do desempenho em tarefas funcionais, por meio do direcionamento do foco de atenção externo. Sentar e levantar são tarefas da vida diária, executadas frequentemente e essenciais para a independência do indivíduo. Por isso, a adoção de métodos que têm como intenção otimizar o desempenho nessas atividades têm grande importância no retorno funcional de indivíduos em reabilitação. Neste contexto, investigamos se instruções para se concentrar externamente produzem benefícios para o desempenho de idosos na tarefa de se transferirem da posição sentada para de pé e de pé para sentado.

Os resultados indicaram que, ao contrário das hipóteses iniciais, não houve efeito positivo do FE no desempenho. Durante o movimento de assentar-se, o FI produziu uma redução da variação dos movimentos da xícara, particularmente, na sua inclinação. No entanto este aparente efeito benéfico do FI não pode ser considerado consistente, uma que vez que todas as outras variáveis de desempenho mostraram efeitos nulos em ambos tipos de foco. Foi observada a presença de uma diferença significativa entre as condições de dificuldade, tanto para levantar quanto para sentar, e a suavidade, indicando uma relação inversa entre suavidade e dificuldade do movimento. Porém, é possível que o aumento na dificuldade da tarefa não tenha sido suficiente para que os efeitos do foco de atenção se manifestassem, mesmo em indivíduos idosos.

Evidências recentes corroboram com os resultados obtidos nesse trabalho, isto é, indicam que o FE não contribui para melhorar o desempenho de atividades cotidianas (DE BRUIN *et al.*, 2009; DE MELKER WORMS *et al.*, 2017; LANDERS, MERRILL R. *et al.*, 2016; MAK *et al.*, 2018; RICHER *et al.*, 2017; YOGEV-SELIGMANN; SPRECHER; KODESH, 2017). Uma possível explicação para esse achado é o fato de que as tarefas de st-dp e dp-st são adquiridas naturalmente ao longo do desenvolvimento motor normal e com poucas instruções declarativas. A literatura sugere que o foco de atenção não é capaz de alterar o desempenho neste tipo de tarefas. Assim, os indivíduos não se beneficiam dos efeitos do FE bem como também não se prejudicam com o FI.

Portanto, podemos concluir que, de acordo com a interpretação dos resultados deste estudo e de outros relacionados com atividades de mobilidade da vida diária, a suposição de que o foco externo deve ser sempre preferido parece não ser suficientemente corroborada.

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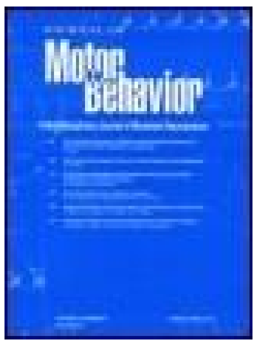

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Attention Focus Does Not Influence Performance of Sit-to-Stand in Young and Older Adults

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ABSTRACT. An external focus of attention can improve performance, but there is little research on effects for the elderly in every day, well-learned mobility tasks. 57 older and 59 young adults performed the sit-to-stand and stand-to-sit while holding a cup, at three difficulty levels (cup empty or full, at normal or fast speed). Half were instructed to focus internally (on their movements) and half externally (on the cup). The effects of focus, age, and difficulty level were tested for movement time, mean inclination of the cup, inclination variability, and smoothness with $2 \times 2 \times 3$ ANOVAs. Significant effects of difficulty were consistent across variables ($p < 0.05$). An effect of focus was present only for the inclination variability of the stand-to-sit ($p < 0.03$), favoring an internal focus (less variability). The age $\times$ focus interaction was significant for mean cup inclination, but *post hoc* tests failed to reveal any significant differences. The results of this study, together with the literature, suggest that an external focus may not benefit the performance of young or older adults in general mobility activities of daily living. The prevalent assumption that an external focus is always beneficial for performance needs further empirical testing.

Keywords: Elderly, focus of attention, mobility

Introduction

Attention can improve motor performance (Wulf, Shea, & Lewthwaite, 2010). Attention can be directed to the effects of movement on the environment (external focus, EF) or to movement itself (internal focus, IF). Extensive literature indicates that an EF produces better performance and learning on a variety of tasks (for a review, see Wulf, 2013). Benefits of an external over an IF of attention are seen in movement efficiency (e.g., muscular activity, force production, cardiovascular responses, etc). In particular, increased muscle fiber recruitment, increased force production, and more effective movement coordination under an EF can potentially increase movement speed (Fasoli, Trombly, Tickle-Degnen, & Verfaellie, 2002; Porter, Nolan, Ostrowski, & Wulf, 2010; Totsika & Wulf, 2003). Positive effects are also observed for movement effectiveness (e.g., accuracy, stability, etc., Wulf, 2013). The reason, according to the "constrained action hypothesis" (Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001), is that an IF may induce conscious control that interferes with automatic coordination, causing performance to suffer. An EF, on the contrary, would favor unconscious, fast and reflexive processes, resulting in greater movement fluidity.

According to the "constrained action hypothesis," the beneficial effects of an EF are especially salient in difficult tasks, when individuals would attempt to consciously intervene in body movement more frequently (Landers, Wulf, Wallmann, & Guadagnoli, 2005; Wulf, Töllner, & Shea, 2007). Therefore, to guarantee sufficiently challenging tasks, most research has focused on inexperienced individuals performing novel sports-related tasks (Wulf, 2007, 2013), while the activities of daily living have received less attention. Would an EF improve the performance of well-learned activities of daily living, such as sit-to-stand and stand-to-sit?

The sit-to-stand and stand-to-sit are fundamental for independence and become more difficult with age. Sit- to-stand and stand-to-sit require greater hip joint moments than stair climbing or walking (Rodosky, Andriacchi, & Andersson, 1989). Additionally, good con- trol of balance is required to deal with the rapid shift of body mass between the seat and the feet (Riley, Schenkman, Mann, & Hodge, 1991). With age-related decreases in muscle strength and balance control, the sit- to-stand and stand-to-sit become more difficult, and many older adults perform the task close to their max- imal abilities (Hughes, Myers, & Schenkman, 1996). Deterioration of sit-to-stand and stand-to-sit performance in older adults is a key indicator of decreased mobility and increased risk of falls (Buatois et al., 2008).

Very frequently, the sit-to-stand and stand-to-sit are performed in association with manual tasks that pose additional control challenges, such as holding a cup full of liquid (Muhaidat, Kerr, Evans, Pilling, & Skelton, 2014). For example, one may be sitting at a table in a cafe, stand up and walk away with a coffee cup. Acceleration and orientation of the cup must be controlled to avoid spilling (Togo, Kagawa, & Uno, 2012) and movement time may increase to accommodate precise stabilization of the cup. The time difference between

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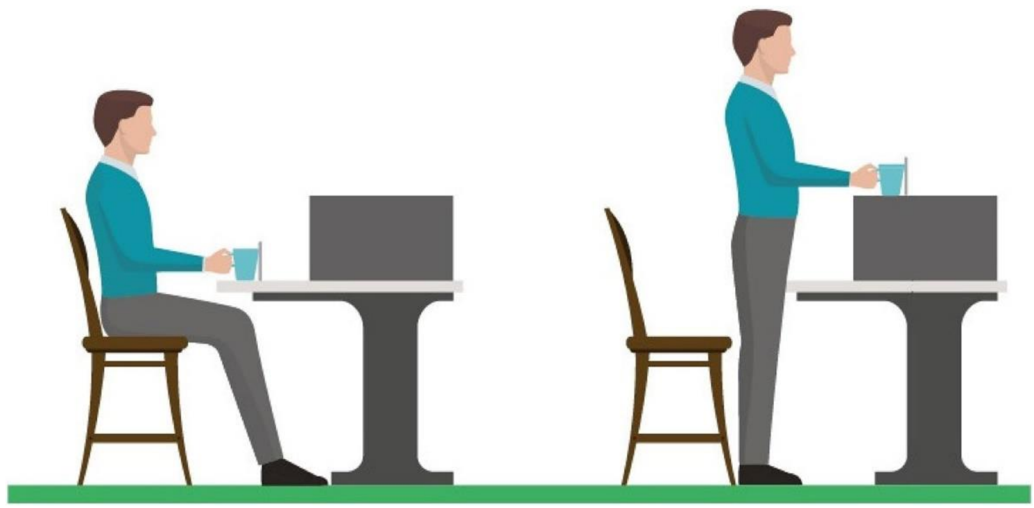

FIGURE 1. Task setup.

the Timed Up and Go test (which involves Si-St and St-Si) with and without holding a cup appears to be a valid marker of frailty and fall risk (Muhaidat et al., 2014; Tang, Yang, Peng, & Chen, 2015; Togo et al., 2012). From an experimental point of view, holding a cup also makes for a useful experimental model because it creates a natural external referent to which attention may or may not be directed during sit-to-stand and stand-to-sit, depending on instructions. Previous studies have shown that an EF on a supra-postural task goal increases movement effectiveness (McNevin & Wulf, 2002; Wulf, Mercer, McNevin, & Guadagnoli, 2004; Wulf, Weigelt, Poulter, & McNevin, 2003).

It is possible that a simple behavioral intervention with EF instructions during sit-to-stand and stand-to-sit would be especially beneficial for the elderly. Older adults are presumably more inclined to consciously control their movements in challenging tasks (Woollacott & Shumway-Cook, 2002). If the "constrained action hypothesis" is correct, conscious attention to body movement (IF) impairs automaticity and fluidity of movement. EF instructions, in contrast, may increase movement fluency, regularity, and speed (Kal, Van Der Kamp, & Houdijk, 2013). Given the fundamental importance of sit-to-stand and stand-to-sit for independence, positive effects of EF instructions could generate interesting clinical applications in rehabilitation treatments for the elderly.

This study, therefore, investigated whether attention focus instruction can have any impact on the well-learned daily life activity of sit-to-stand and stand-to-sit holding a cup, for young and older adults, in three different task difficulty levels. We hypothesized that focus instructions would interact with age and difficulty level, being especially beneficial in more difficult conditions and for older people, at the level of movement outcome. We expected that EF instructions would produce greater movement efficiency, that is, shorter movement times. We also expected EF instructions would produce greater movement effectiveness with respect to the overall goal of keeping the cup vertical and stable during the transfer to avoid spilling. More specifically, we expected that for older people in the most difficult condition, the EF would lead to faster sit-to-stand and stand-to-sit transitions, and to cup trajectories with less inclination (more accuracy), and increased smoothness and less variability (more stability).

Method

Participants

The inclusion criteria for this study were: (1) age between 18 and 40 years or over 60; (2) no musculoskeletal symptoms affecting sit-to-stand and stand-to-sit; (3) no cognitive disorder affecting the ability to follow instructions. Participants that felt pain or discomfort during the task (2 older adults) or who were unwilling to complete it (1 young and 4 older adults) were excluded. A total of 59 healthy young adults (44 females) and 57 healthy older adults (41 females) signed consent for participation (approved by the Institution's Ethics Committee) and completed the study.

Task and Apparatus

Participants stood up and sat down from a chair (0.47 m high) holding and transferring a cup (with a

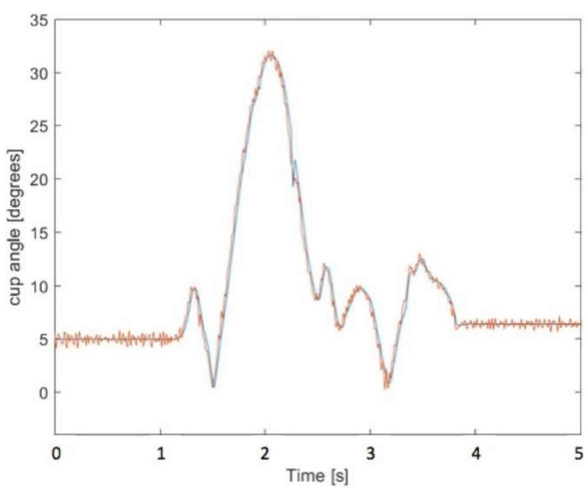

FIGURE 2. Example of cup angle series from inertial sensors (orange) and from an optoelectronic system (blue) during a sit to stand movement.

smartphone attached) between two surfaces of different heights (0.79 and 1.07 m) Figure 1). A Motorola smartphone (Android XT1058) with Sensor Kinetics Pro (Innoventions, Inc.) with a magnetometer, a gyroscope, and linear acceleration sensors was used to record the data.

Procedures

Data collection of daily life tasks in ecologically valid situations has been greatly facilitated by the development of valid and reliable smartphone technology (Boonstra et al., 2006; Galán-Mercant, Barón-López, Labajos-Manzanares, & Cuesta-Vargas, 2014; Nishiguchi et al., 2012). We used an android-based application and sensors after comparison with data from an optoelectronic system (10 cameras, Oqus Qualisys, Sweden), a gold standard for kinematic analysis. Four retro-reflective markers were placed on the smartphone. One participant performed five repetitions of the task in each of three different task difficulty levels. We expected that dependent measures averaged over five repetitions would be representative of typical performance in each experimental condition. Angle time series collected simultaneously from the two systems were compared. Figure 2 shows an example of a cup angle series from the two systems in a sit-to-stand movement. The relative difference between the two series, averaged over time, with the Qualisys as a reference, varied from 0.26 to 0.29%. These tests indicated the validity of sensor data.

In line with a clinical trial rationale, participants were assigned to one of two intervention groups in counterbalanced order, as they enrolled for the study: EF instructions (29 young and 27 older adults) or IF instructions (30 young and 30 older adults). All participants sat on a chair (Figure 1) and were instructed to grab the cup with their non-dominant hand (according to self-reported handedness) and transfer it from the lower to the higher surface as they rose from the chair, or transfer it from the higher to the lower surface as they sat down, always looking straight ahead. The EF group was instructed to ñthink all the time about the cup and the liquid inside the cup.ò The IF group was instructed to ñthink about your own arm and the coordination of your movementsò.

Participants performed three blocks of five trials each, under three difficulty levels: (1) empty cup at normal speed (EN); (2) full cup at normal speed (FN); and (3) full cup at a fast speed (FF). Normal and fast speed were self-chosen for each participant. For normal speed, participants were told to perform the task as they usually do in daily life. For fast speed, they were told to perform the task as fast as they could without spilling liquid. Colored adhesive tape was used to mark and maintain a standard level of liquid in the cup (1 cm below the rim). In case of spilling, the trial was discarded, the liquid was refilled to the mark and the participant was asked to repeat the trial. Focus instructions were reinforced before each condition.

Participants then answered three questions: (1) *what did you focus on while performing the task?*; (2) *were you able to follow the instruction of attention focus?*; and (3) *on a scale of 0 to 10, how well did you follow the instruction?*

Data Reduction

Given the requirements of smartphonesô operating systems, the main issue with their inertial sensors is the variability of acquisition rate (30ï 90 Hz). After spectral density analysis showed no relevant power above 10 Hz, linear interpolation was used to achieve a fixed common sampling frequency of 30 Hz for all three sensors. Data was then filtered with a low pass Butterworth filter of order 3 and cutoff frequency of 10 Hz. An automated Matlab (MathWorks Inc.) routine aided by visual analysis of the accelerometer time series determined timestamps for the start and end of each sit-to-stand and stand-to-sit. Movement time was defined in seconds.

The angle (radians) of the cup with respect to the global vertical was calculated. The magnetometer was used to mark a three-dimensional vector whose variation from an initial position is taken as an inclination (the cup and smartphone were vertical while resting on a table before beginning and after the end of the movement). The inclination was then projected to the vertical axis to calculate the smartphone angle (parallel to the cup). Magnetometer signals are noisy so data from the other sensors are used to improve it. The magnetometer signal is interpolated to optimally reduce the error of its

TABLE 1. Significance values (p) for ANOVAs including participants who reported attention content appropriate to instructions (91).

	Movement time		Inclination average		Inclination variability		Smoothness	
	Sit to Stand	Stand to Sit	Sit to Stand	Stand to Sit	Sit to Stand	Stand to Sit	Sit to Stand	Stand to Sit
Age	0.648	0.788	0.335	0.349	0.951	0.121	0.578	0.578
Focus	0.746	0.636	0.745	0.990	0.224	0.002	0.891	0.891
Difficulty	0.001	0.001	0.003	0.002	0.027	0.014	0.001	0.001
Age×Focus	0.425	0.247	0.042	0.029	0.632	0.847	0.086	0.086
Difficulty×Age	0.040	0.054	0.961	0.943	0.681	0.760	0.809	0.809
Difficulty ×Focus	0.705	0.220	0.995	0.979	0.751	0.536	0.632	0.632
Difficulty×Age×Focus	0.334	0.544	0.714	0.788	0.481	0.356	0.941	0.941

Statistically significant values are in bold.

derivatives compared to the gyroscope and accelerometer. The resulting signal is an estimate of the cup angle. The average and standard deviation of the cup angle over time, for the duration of a sit-to-stand and stand-to-sit, were obtained for each trial.

Smoothness is a measure of the shape of a movement time series. While jerky and irregular movements have low smoothness, steady, regular, and fluent movements are smoother. Smoothness was calculated with the negative spectral arc-length measure, as defined by Balasubramanian, Melendez-Calderon, and Burdet (2012). For each cup angle speed profile $v(t)$, $t \in [0, T]$ and duration T, we generated its Fourier magnitude spectrum. Then negative of the arc length is calculated as

$$\eta_{sal} = -\int_0^{\omega_c} \sqrt{\left(\frac{1}{\omega_c}\right)^2 + \left(\frac{d\hat{V}(\omega)}{d\omega}\right)^2}\, d\omega$$

$$\hat{V}(\omega) = \frac{V(\omega)}{V(0)}$$

where $V(\omega)$ is the Fourier magnitude spectrum of $v(t)$, and $[0, \omega_c]$ is the frequency band occupied by the cup movement. Greater values of this measure indicate smoother movements.

Statistical Analysis

Means and standard deviations (mean ± SD) were used as descriptive statistics. Participants' mean age was compared between IF and EF groups with independent samples t-tests. A chi-square test was used to compare the frequency of males and females between IF and EF groups. The two-proportion z test was used to test whether the frequency of discarded trials (due to spilling) was different between IF and EF groups. Adherence to instructions was compared across groups with Fisher's exact tests for categorical answers (question 2) and a 2 (age) × 2 (focus) ANOVA for score-based answers (question 3). Sit-to-stand and stand-to-sit performance variables were analyzed separately. The dependent variables of interest were the average and standard deviation of cup angle over time, smoothness and movement time. Data were analyzed with a 2 (Age) × 2 (Focus) × 3 (Difficulty level) analysis of variance (ANOVA), with repeated measures on the last factor. All statistics were calculated using the Statistical Package for the Social Sciences Version 21.0 (SPSS for Windows, Chicago, IL). Statistical significance was set at $p < 0.05$.

Results

Participant Characteristics in the Two Attention Instruction Groups

A total of 116 participants (57 right-handed in IF and 50 right-handed in EF, 3 left-handed in IF and 6 left-handed in EF) took part in this study. The frequency of females and males was not statistically different ($p = 0.823$) among young participants in the IF (22 females, 8 males) compared to the EF (22 females, 7 males) group, or among old participants ($p = 0.152$) in the IF (24 females, 6 males) compared to the EF (17 females, 10 males) group. Mean age also did not differ ($p = 0.199$) between young participants in IF (24.90 ± 3.26) and EF (23.72 ± 3.68) groups (overall mean: 24.32 ± 3.50) or old participants ($p = 0.532$) in IF (68.37 ± 5.60) and EF (69.37 ± 6.46) groups (overall mean: 68.84 ± 5.99).

Ability to Follow Instructions

For the question "*were you able to follow the instruction of attention focus?*" the proportion of "Yes" responses among old participants for EF (96.3%) and IF (89.7%) were not statistically different ($p = 0.612$). The proportion of "Yes" responses among young participants for EF (96.6%) and IF (100%) were also not statistically different ($p = 0.491$).

For the question "*on a scale of 0 to 10, how well did you follow the instruction?*" the average scores for the older adults under EF and IF instructions were respectively, 8.61 ± 1.09 and 8.62 ± 1.30. The average scores

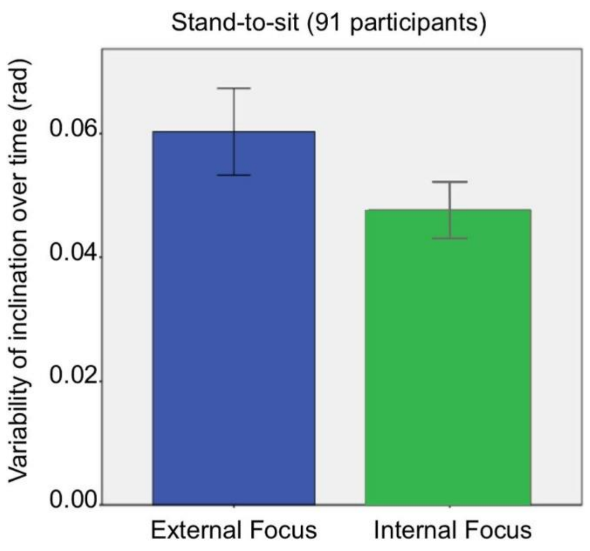

FIGURE 3. Significant difference in the variability of inclination (standard deviation over time) between focus groups for the stand-to-sit. Error bars indicate ± 2 standard errors.

for the young adults under EF and IF instructions were respectively, 8.41 ± 0.92 and 8.05 ± 1.10. Age, Focus, and the Age × Focus interaction were not significant ($p > 0.063$).

The content of answers to "*what did you focus on while performing the task?*" revealed, however, that many individuals had difficulty to focus on actual internal content. A total of 8 of the 30 older adults (26.6%) and 13 of the 30 young adults (43.3%) in the IF group gave answers indicating content inappropriate to received instruction. For example, some participants answered that they had "focused on not spilling," or "on looking straight ahead instead of looking at the cup." In contrast, 2 of the 27 older adults (7.40%) and 2 of the 29 young adults (6.89%) in the EF group gave answers indicating content inappropriate to received instruction.

Thus, we ran statistical ANOVAs of the effects of EF and IF on performance only for the 91 participants whose answers ensured they had used attention content that was appropriate to their respective instructions. Table 1 shows all ANOVA p values.

Performance (Movement Outcome Measures)

Table 1 shows that the main effect of Difficulty was significant for all variables. The effects of Difficulty were clear in movement time, which was significantly different ($F_{2, 174}$ ¼ 62.616, p ¼ 0.001, partial g^2 ¼ 0.419 for sit-to-stand and $F_{2, 174}$ ¼ 52.518, p ¼ 0.001, partial g^2 ¼ 0.376 for stand-to-sit) between the three difficulty levels: empty cup at normal speed (3.707 ± 0.113 for sit-to-stand and 4.046 ± 0.121 for stand-to-sit); full cup at normal speed (4.545 ± 0.129 for sit-to-stand and 4.913 ± 0.150 for stand-to-sit); and full cup at a fast speed (3.778 ± 0.103 for sit-to-stand and 4.002 ± 0.123 for stand-to-sit).

However, there were no significant differences in movement time ($F_{2, 174}$ ¼ 0.106, p ¼ 0.746, partial g^2 ¼ 0.001 for sit-to-stand and $F_{2, 174}$ ¼ 0.226, p ¼ 0.636, partial g^2 ¼ 0.003 for stand-to-sit) between the IF (4.044 ± 0.160 for sit-to-stand and 4.377 ± 0.180 for stand-to-sit) and EF groups (3.976 ± 0.137 for sit-to-stand and 4.264 ± 0.154 for stand-to-sit). No significant interaction effects involving Focus were significant (p P 0.220).

Movement time also did not differ significantly ($F_{2, 174}$ ¼ 0.210 p ¼ 0.648, partial g^2 ¼ 0.002 for sit-to-stand and $F_{2, 174}$ ¼ 0.073, p ¼ 0.788, partial g^2 ¼ 0.001 for stand-to-sit) between young participants (3.962 ± 0.153 for sit-to-stand, 4.352 ± 0.172 for stand-to-sit) and old participants (4.058 ± 0.145 for sit-to-stand, 4.288 ± 0.163 for stand-to-sit). There were significant Difficulty × Age interaction effects for movement time ($F_{2, 174}$ ¼ 3.284, p ¼ 0.040, partial g^2 ¼ 0.036 for sit-to-stand and $F_{2, 174}$ ¼ 2.974, p ¼ 0.054, partial g^2 ¼ 0.033 for stand-to-sit), suggesting that difficulty may affect movement time for young and old participants differently. Given that the main effect of difficulty was quite consistent across variables, and that the focus of our analysis was on Focus, but not Difficulty or Age effects, these interactions were not further investigated.

A significant main effect of Focus was present only for inclination variability of the stand-to-sit, ($F_{1, 87}$ ¼ 10.131, p ¼ 0.002, partial g^2 ¼ 0.104). The group average values (IF: 0.049 ± 0.003; EF: 0.063 ± 0.003) indicate that variability of angle was significantly higher for EF compared to IF (Figure 3).

An Age × Focus interaction effect was significant only for the average inclination angle during the sit-to-stand ($F_{1, 87}$ ¼ 4.266, p ¼ 0.042, partial g^2 ¼ 0.047 for sit-to-stand and $F_{1, 87}$ ¼ 4.945, p ¼ 0.029, partial g^2 ¼ 0.054 for stand-to-sit). However, Bonferroni-corrected post hoc independent t tests showed no differences for sit-to-stand for the young participants (p ¼ 0.267) between IF (0.141 ± 0.064) and EF (0.176 ± 0.116), or for old participants (p ¼ 0.127) between IF (0.207 ± 0.135) and EF (0.158 ± 0.063). Results were similarly not significant in the stand-to-sit for young participants (p ¼ 0.121) between IF (0.139 ± 0.060) and EF (0.190 ± 0.122), or for old participants (p ¼ 0.177) between IF (0.208 ± 0.147) and EF (0.160 ± 0.073). These results are shown in Figure 4. No other interactions involving Focus were significant.

The frequency of discarded trials (due to spilling) did not differ (p ¼ 0.144) between the groups receiving IF (12 out of 900 trials) or EF instructions (19 out of 840 trials).

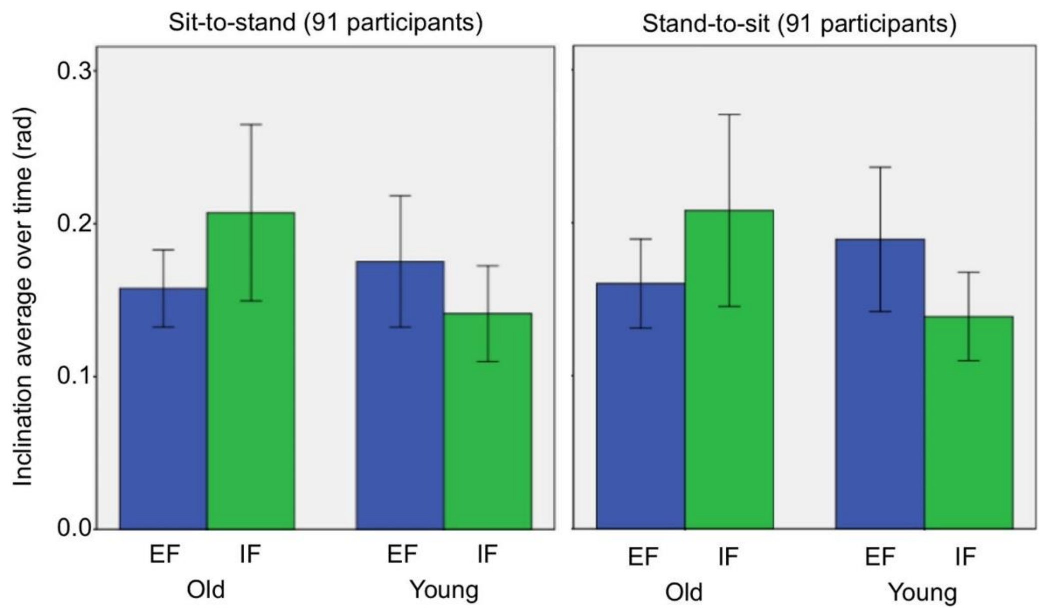

FIGURE 4. Comparison of inclination average over time for older and younger participants in the external focus (EF) and internal focus (IF) groups. No pairwise comparisons were significant. Error bars indicate ± 2 standard errors.

Discussion

The effects of attention focus on activities of daily living are rarely investigated. Adequate sit-to-stand and stand-to-sit performances are fundamental for maintaining independence in old age. Positive effects of focus instructions could be used in rehabilitation applications to improve the performance of this task. Thus, our trial investigated whether focus instruction interventions had any impact on performance (at the level of movement outcome) of the well-learned activity of sit-to-stand and stand-to-sit while holding a cup, for young and older adults, at three difficulty levels. We hypothesized that in the most difficult condition, for older people, an EF would lead to greater movement effectiveness, that is, less cup inclination, lower variability, and increased smoothness. The results did not support our hypothesis.

We failed to find significant focus effects except for worse angle stability under EF compared to IF for the stand-to-sit. However, this effect was not consistent, as all other performance variables showed null focus effects. Our null results are surprising in view of the conclusion of a literature review indicating that the enhancements in motor performance with an EF compared to IF are well established. The review author states: ñThe breadth of this effect is reflected in its generalizability to different skills, levels of expertise, and populations é ò (Wulf, 2013, p. 99). Our results are inconsistent with this claim. In our study, an EF did not enhance the motor performance of sit-to-stand and stand-to-sit while holding a cup, a skill that involves body transfer and object manipulation (Gentile, 2000), regardless of difficulty level and population. What factors may explain these null results?

First, we need to point out that we controlled for adherence to instructions. Self-reported adherence scores were similar across conditions and groups. However, several individuals (21%) reported focusing on content inconsistent with the instructions they had received. Our analysis included only individuals with appropriate attention content. Therefore the lack of focus effects cannot be attributed to inadequate adherence to instruction.

Second, our results are consistent with many recent studies involving day-to-day posture and mobility skills. Despite some previous research showing benefits of an EF for these kinds of skills (Chiviacowsky, Wulf, & Wally, 2010; McNevin, Weir, & Quinn, 2013; Richer, Saunders, Polskaia, & Lajoie, 2017), several studies report null effects for focus instructions for posture and mobility skills (De Bruin, Swanenburg, Betschon, & Murer, 2009; Landers, Hatlevig, Davis, Richards, & Rosenlof, 2016; Mak, Young, Chan, & Wong, 2018; Melker Worms et al., 2017; Richer, Polskaia, & Lajoie, 2017; Yogev-Seligmann, Sprecher, & Kodesh, 2017).

Richer, Polskaia, and Lajoie (2017) found no difference between IF and EF for control of quiet stance in older adults. For gait performance, no effects on walking stability or balance recovery after gait perturbations were found for older adults (Melker Worms et al., 2017). Yogev-Seligmann et al. (2017) reported that gait variability could not be improved by focusing on keeping steps consistent or focusing on pacing gait to the rhythm of a metronome. Both focus instructions actually increased the variability of some spatiotemporal gait parameters. Mak et al. (2018) found that although IF appears to compromise gait stability, EF instructions did not improve gait stability compared to a control condition in older adults. Benefits of an EF were again not found in a randomized controlled trial on the learning of balance skills for the healthy elderly (De Bruin et al., 2009) or patients with Parkinson's Disease (Landers et al., 2016). No studies examining the effects of attention focus on the performance of the sit-to-stand and stand-to-sit were found. Our study appears to be the first on the topic, and our results are consistent with many experiments involving activities of daily living.

In the attention focus literature, the lack of benefits of EF instructions has been attributed to different factors. Researchers have argued that the benefits of an EF do not apply to movement tasks (i) that do not involve implements and have no clearly intended environmental effect (Melker Worms et al., 2017); (ii) that are too easy (Landers et al., 2016; Wulf, 2008); or (iii) that were learned in early childhood without declarative knowledge (Melker Worms et al., 2017). We will argue below that the first two reasons are not pertinent to our study, with the third reason being the most probable explanation for our results.

The first argument is that the benefits of an EF would not apply to movement tasks that do not involve action on specific objects. Usually, during sit-to-stand and stand-to-sit, the individual does not intend to produce any specific effects on external objects. In such tasks, an EF may in fact not benefit performance (see, e.g., Lawrence, Gottwald, Hardy, & Khan, 2011). In this study, however, we associated an object-manipulation goal to the sit-to-stand and stand-to-sit. This ensured a natural external reference to which attention could natur- ally be directed, depending on instructions. Our perform- ance variables specifically reflect effectiveness to control the environmental effects of movement: the cup average angle, its stability, and smoothness. Thus, we expected that the benefits of an EF would apply to the performance of our task, but no advantages of an EF were found. Also, the lack of effects on movement time suggests that sit-to-stand and stand-to-sit, as a whole, were not affected.

Second, the literature indicates that an EF is purportedly more beneficial in difficult tasks, because it would prevent attempts to consciously intervene in body movement (Landers et al., 2005; Wulf, 2008; Wulf et al., 2007). To avoid a lack of effects due to unchallenging conditions, our task had three difficulty levels. Our design is limited in that it did not include a possible intermediate difficulty condition with an empty cup at fast speed. However, performance results show that our difficulty manipulation significantly affected all variables, for both age groups.[1]

The sit-to-stand and stand-to-sit with a full cup at the fastest possible speed correspond to the most difficult real-life version of the task. With no EF benefits on movement effectiveness and movement time for this ver- sion of the task, effects in any other less challenging, ecologically valid versions are unlikely.

This brings us to the third, most probable explanation for results: possibly, general postural and mobility skills that are acquired spontaneously during normal motor development with little declarative instruction (phylogenetic skills such as the sit-to-stand) are less vulnerable to interferences of attention focus (Melker Worms et al., 2017; Young & Mark Williams, 2015). Specialized complex skills learned later in life (ontogenetic skills such as sports gestures), in contrast, are usually acquired with great amounts of explicit instruction in early practice (Masters & Maxwell, 2008). For these tasks, an IF may revert the individual back to an earlier declarative stage of learning and interfere with the automaticity of control, while an EF might prioritize relevant, goal-related information for fluent coordination (Melker Worms et al., 2017; Young & Mark Williams, 2015). We speculate that because the sit-to-stand is a phylogenetic mobility skill, it would be less prone to the negative effects of an IF or the positive effects of an EF.

Interpretations of this study's results in the context of the available literature for general postural and mobility activities of daily living suggest that an EF of attention may not benefit the performance of healthy young and older adults in well-learned tasks. They indicate that the assumption that an EF is to be always preferred (Wulf, 2013, 2016; Wulf et al., 2007) needs further empirical testing for activities of daily living. This study is limited in that it did not assess coordination but only performance measures at the level of movement outcome. An EF might positively affect the coordination of postural and mobility tasks for example in individuals with neurological health conditions that impair automaticity of movement.

Note

1. Note that the small difference in movement time (0.089s) between EN and FF does not invalidate our classification of difficulty. Participants used similar times in these two conditions because when the cup was full, they had to slow down to avoid spilling. When the cup was empty, they felt comfortable moving faster as there weren't any negative consequences. FF is the hardest and EN is the easiest of the three conditions.

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