Effects of Age, Task Complexity, and Exercise on Reaction Time of Women During Ambulation Tasks

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ABSTRACT

Purpose: Reaction time (RT) is defined as the time lapse between the onset of a stimulus and the initiation of a response. The purpose of Study 1 was to compare RTs of young and elderly women during ambulation. The purpose of Study 2 was to investigate the effects of regular exercise on RTs of elderly women during ambulation tasks. **Methods:** Reaction times were measured using a portable computer, 2 transistor radios, and a radio interface box. The computer generated an auditory signal to which participants reacted by pushing a hand-held switch. Reaction times were compared in Study 1 between 17 healthy elderly women and 13 university students and in Study 2 between 15 exercising and 16 non-exercising elderly women. Testing of each participant occurred during sitting, walking on tile, and walking on foam padded carpet. **Results:** The results of Study 1 revealed differences in RT between the 2 groups and between the sitting and the 2 walking conditions, but no interaction between group and task complexity. The results of Study 2 revealed differences among all conditions, but not between groups. **Conclusions:** The surprising result of Study 1 was that the elderly were not compromised to a greater extent than the young by increased task complexity. This suggests less age related RT decline during familiar activities. Results of Study 2 showed that level of exercise did not differentiate elderly participants' performance on RT. This may be because the active lifestyle of both groups of participants was more important in maintaining RT than a formal exercise program.

Key Words: reaction time, task complexity, aging

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INTRODUCTION

As the proportion of older individuals in the United States continues to rise, it is increasingly important that they are able to remain mobile and independent. There are many changes associated with growing older, including a general decline in sensorimotor function, which may impair ability to perform activities of daily living (ADLs) safely and independently.[1] A critical element in the safe performance of ADLs is the ability to react to incoming stimuli. This highly complex information processing involves not only the execution of a movement, but also receiving and identifying sensory signals; choosing appropriate actions; and integrating, sequencing, timing, and coordinating movement output.[2-4]

One measure of information processing is reaction time (RT). Reaction time is an external indicator of the ability of the nervous system to receive, process, and initiate a response to incoming stimuli. Reaction time is defined as the time lapse between the onset of a stimulus and the initiation of a movement response. Responses that take more time to initiate are assumed to require longer information processing times, and are thus considered to be more complex to the central nervous system.[1,2,5] One persistent finding in the literature is a slowing of responses with advancing age.[1,2,5-7] This slowing involves all types of motor responses, from simple to complex. Salthouse,[7] in his review of over 50 studies, found that increased age was consistently associated with increased RT for a variety of research paradigms. Although an assortment of hypotheses has been forwarded to explain this age related change, it is believed that an increase in RT indicates slowed central processing, as sensory receipt and motor outflow times are believed to remain similar across the lifespan.[2,3] Most authors agree that older adults go through the same central nervous system processing as younger adults, but at a slower rate and that this slowing could be responsible for functional age related changes such as an increased risk of falls.[8]

Other age related influences on RT include task complexity. A strong interaction between task complexity and age has been established.[9-16] With simple tasks, elderly individuals consistently have slightly slower RTs than their younger counterparts. As tasks become more complex, however, performance of the elderly degrades to a greater extent than that of young people. Because the elderly consistently demonstrate increased RTs with even simple tasks requiring minimal cognitive processing, it is believed that slowing of RT is further amplified during more complex tasks requiring deeper cognitive processing.[5,7,16]

A second factor affecting RT is the familiarity of the task being performed. A limitation of current literature is that RT studies are typically conducted in laboratory settings, with subjects seated at computers, responding to visual or auditory stimuli with a finger or upper extremity via a switch or computer key.[9-12,16-18] Sit and Fisk[19] found that the RT gap between younger and older adults narrowed with task familiarity. Their findings raise questions of whether RT differences between young and elderly persist as familiar, functional tasks become increasingly complex.

Aerobic exercise is a third factor affecting RT. Most research has shown that regular exercise lessens age-related slowing of RT.[20-25] However, several authors have reported that beginning an aerobic fitness program does not significantly improve RT.[26,27]

Based upon limitations in the current literature, we generated 2 related RT studies. To clarify the impact of task familiarity on age-related change in RT, the purposes of Study 1 were to compare RTs of young and elderly women while sitting and ambulating, and to determine if increasing complexity of gait tasks had a similar effect on RTs of young and elderly. We hypothesized that: (1) differences in RTs between the 2 groups would exist, with the elderly responding more slowly, and (2) differences between age groups would be only slightly accentuated with increasing task complexity, due to the familiarity of the tasks being performed.

The purpose of Study 2 was to investigate the effects of regular exercise on RT of elderly women during ambulation tasks of varying complexity. We hypothesized that: (1) elderly women who participated in regular aerobic exercise would have faster RTs than their non-exercising counterparts during ambulation tasks, and (2) as task complexity increased, RTs of non-exercisers would degrade to a greater extent than those of regular exercisers.

METHODS

Instrumentation

Reaction times were measured using a Northgate ZX portable computer (Northgate Computer Systems, Inc., Eden Prairie, Minn), 2 transistor radios, and a radio interface box (Figure 1) which was designed for this research. The computer generated an auditory signal to which the participants responded by pushing a finger switch held in their dominant hand. The switch was connected to a Realistic FM microphone (Radio Shack, Fort Worth, Tex), which was attached to the belt of the participant. The microphone was tuned to an FM radio frequency corresponding to that of a transistor radio. Participants' responses were transmitted from the hand-held switch to the microphone, then via the radio and radio interface box, to the computer. Reaction time was recorded to the nearest millisecond.

A heel switch set inside a foam shoe insert was placed in the shoe of each participant's dominant foot. During ambulation, this switch was triggered by heel strike. A signal was then

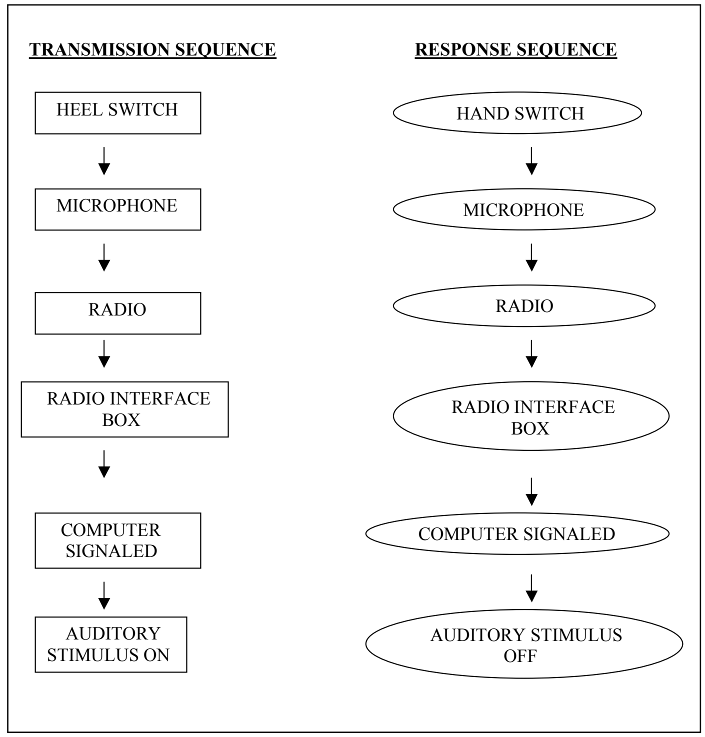

Figure 1. Equipment for transmission and response sequence.

transmitted via a second microphone and transistor radio to the computer. This signal was used to assure that the auditory signal to which the participants responded was generated during stance of the dominant foot at randomized intervals, 0-0.4 milliseconds, from heel strike.

Participants

Participants for Study 1 were a group of 17 healthy elderly women (age range 60-68 years, mean 67.1 years) and a second group of 13 female university students (age range 22-26 years, mean 24.4 years). Participants for Study 2 were 31 women ranging in age from 65 to 82 years. Fifteen women, who participated in regular aerobic activity at least 3 times per week for 30 minutes, were recruited for the exercising group (mean age 69.3 years) and 16 women, who exercised once per week or less, were recruited for the non-exercising group (mean age 74.1 years).[28] Potential participants for both studies were excluded if they had significant orthopaedic, neurological, cardiac, or hearing impairments.

Procedures

Prior to participation, participants read and signed a consent form approved by the Committee on Research at the University of Indianapolis. Participants also completed a questionnaire with demographic information, details of activity level, and medical history. Participants' height and weight were recorded. Hand function and hearing screens were performed to determine eligibility. For Study 2, participants also completed an exercise habits questionnaire.

Overall research design consisted of testing each participant on 3 consecutive days measuring blocks of 30 RT trials.

Thirty trials were used because pilot testing revealed comparable mean performances with 30 and 60 trials, making 30 the efficient choice for the study. Three conditions were tested: sitting, walking on tile, and walking on foam padded carpet. The foam padding was added following pilot testing to further differentiate task difficulty. The order of conditions was counterbalanced. Participants were allowed a 1-minute rest between conditions. Auditory signals were given at random intervals. For the walking conditions, 2 walkways, each 3 feet wide by 30 feet long were used. The first walkway was standard linoleum. In Study 1, the second walkway consisted of 1 half-inch foam pad covered with thick pile carpeting. In Study 2, Temper Foam (Kees Goebel Medical, Hamilton, Ohio) padding of varying densities was used instead to further differentiate between the ambulation tasks.

Prior to testing, participants were familiarized with equipment and testing procedures. The heel switch and foam insert were placed inside the shoe of each participant's dominant foot, and the hand-held switch was placed in the dominant hand. In both studies, participants walked at a comfortable pace down each walkway. For each condition on each day, participants were given 3 practice trials. They were instructed to respond as quickly as possible to the auditory signal by pressing the hand-held switch with their index finger. During each trip down the walkway, a random number of auditory signals was given.

Data Analysis

Means and standard deviations for RTs were calculated for all conditions. Day 3 data were used for all data analyses, because it was determined during pilot testing that learning effects had stabilized by Day 3. A 2 (group) X 3 (condition) mixed design ANOVA was used to analyze differences. In Study 1, the 2 levels of group were young and elderly women, and the 3 levels of condition were sitting, walking on tile, and walking on foam-padded carpet. In Study 2, the 2 levels of group were exercising and non-exercising elderly women and the 3 levels of condition were sitting, walking on tile, and walking on varying density foam-padded carpet. Paired t-tests with Bonferroni corrections were used for post hoc analysis. Alpha was set at 0.05 for the 2 ANOVAs and 0.017 for the multiple comparisons. The Statistical Package for the Social Sciences (version SPSS X) was used for data analysis.

RESULTS

Study 1

Reaction time data are presented in Table 1. Mean times ranged from 199.2 milliseconds for young women who were tested in sitting to 263.9 milliseconds for elderly women who were tested while walking on carpet. Results of the 2 X 3 ANOVA are summarized in Table 2. Significant differences were found for the main effects of group ($F=12.39$; $p=0.001$) and condition ($F=20.97$; $p < .001$). No interaction between group and condition was found, illustrating a similar pattern of change for both groups. Post hoc analyses for main effects of condition revealed statistically significant differences between RTs during sitting and walking on tile ($p < .001$), and sitting and walking on carpet ($p < .001$), but not between the 2 walking conditions ($p = 0.387$).

Study 2

Reaction time data are presented in Table 1. Mean times ranged from 226.0 milliseconds for non-exercising women who were tested in sitting to 262.6 milliseconds for exercising women who were tested while walking on carpet. Results of the 2 X 3 ANOVA are summarized in Table 2. The main effect for group was not significant, indicating that the exercisers and non-exercisers performed similarly on the RT tasks. The main effect for condition was significant ($F=18.68$; $p < .001$). No interaction between group and condition was found, illustrating a similar trend of performance between exercisers and non-exercisers. Post hoc analyses for the main effect of condition revealed significant differences among all 3 conditions.

DISCUSSION

The purposes of these studies were to compare reaction times of young, elderly exercising, and elderly non-exercising women during tasks of varying complexity. Our results supported the slowing of RT with age and with increasing task complexity.[1,2,5-7,9-11,13,14,17,29] Results, however, refuted literature that has suggested that RTs of the elderly degrade to a greater extent than those of young people or that RTs of elderly non-exercisers are slower and degrade to a greater extent with task complexity than those of elderly exercisers.[7,10-12,16,17,20,22-25,31]

Study 1

Results of Study 1 supported our first hypothesis, and many previous findings, that suggested slowed RT with advancing chronological age.[1,2,5-7,11,13,14] Our findings support and add to existing literature by showing that slowing also applies to RTs during functional activities, specifically ambulation. Results also support our second hypothesis, and previous findings, revealing increasing RTs for both young and elderly groups with more complex tasks.[7,9-11,17,29]

The surprising result of this investigation, however, was a lack of group by condition interaction. These results refute findings of most previous studies that show the elderly penalized to a greater extent than young people by increases in task complexity,[7,10-12,16,17] but support findings of a minority of authors who have reported no significant differences between young and elderly during divided attention tasks.[11,30] McDowd and Craik[11] concluded that repetitive tasks require relatively automatic processing. The lack of deterioration of RT for the older women during the repetitive and automatic gait task suggested that familiar activities might require less cognitive processing.[8,19]

Study 2

The results did not support our first hypothesis in Study 2, or many previous findings, which suggested that exercisers have faster RTs than non-exercisers.[20,22-25,31] Our results supported the findings of Panton et al[26] and Roberts[27] who found

Table 1. Mean and Standard Deviation (SD) for Reaction Times (in milliseconds) Obtained from Young and Elderly Groups Tested Under 3 Conditions in 2 Studies

STUDY	GROUPS	SITTING Mean ± SD	TILE Mean ± SD	CARPET Mean ± SD
1	Young n=13	199.2 ± 44.9	215.7 ± 44.9	211.7 ± 40.3
	Elderly n=17	235.2 ± 72.5	261.1 ± 84.6	263.9 ± 90.2
2	Exercisers n=15	233.7 ± 53.0	258.9 ± 77.7	262.6 ± 76.2
	Non-Exercisers n=16	226.0 ± 53.0	240.4 ± 68.1	253.8 ± 75.2

Table 2. Results of 2 X 3 Mixed Design Analysis of Variance for 2 Studies

STUDY 1					
SOURCE	SS	D F	MS	F	P
Group	0.51	1	0.51	12.39	0.001
Error	1.15	28	0.04		
Condition	0.19	2	0.10	20.97	<.001
Group X Condition	0.01	2	0.01	0.69	0.505
Error	0.26	56	0.01		
STUDY 2					
SOURCE	SS	D F	MS	F	P
Group	0.10	1	0.10	1.01	0.324
Error	2.83	29	0.10		
Condition	0.40	2	0.20	18.68	<.001
Group X Condition	0.02	2	0.01	0.89	0.415
Error	0.62	58	0.01		

no significant decrease in RT after participation in an exercise program.

Our second hypothesis was also refuted. As task complexity increased, RTs of the non-exercising group did not degrade to a greater extent than those of the exercising group. Results of the post hoc analysis indicated that task complexity was adequately addressed; however, both groups performed similarly as task complexity increased. Lupinacci et al believed this 'dampening' of the positive effects of exercise on RT seen with increasing task complexity, was due to the inclusion of socially active participants.[33]

It may be that simply leading an active lifestyle minimizes RT declines for the elderly by assisting with maintenance of central cognitive processing. Whitehurst conducted an aerobic training study with participants who met certain criteria for active lifestyles, similar to our participants.[32] He concluded that while aerobic training may benefit sedentary individuals, aerobic conditioning did not directly improve RT in the elderly population beyond a certain normal 'threshold.' He concluded that health status and lifestyle are stronger determinants of RT in older women than specific aerobic fitness level.

There were several limitations to these studies. Participants were instructed to walk at a comfortable pace making it possible that non-exercisers could have slowed their gait enough to decrease the challenge of the task, increase concentration, and thereby have more comparable RTs to the exercisers. Internal validity could have been compromised by testing different participant groups at different settings. Further, no formal hearing evaluation was performed and deficits in hearing could have falsely inflated RTs. Finally, all participants were volunteers who were active and free of significant health problems and, therefore, may not be representative of the general elderly female population.

CONCLUSIONS

The results of these studies are clinically important because they reflect the ability of the elderly to safely and independently perform ADLs. The overall slowing of RT in older women is not as prominent during functional tasks such as gait, as compared with previous RT investigations performed within unfamiliar laboratory contexts. It may be that prior research has given the impression that the RT of the elderly deteriorates to a greater extent than is actually the case for daily tasks. Further, an active lifestyle rather than a specific aerobic exercise program may be sufficient for combating age-related sensorimotor decline.

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