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ORIGINAL ARTICLE

COGNITIVE AND MOTOR PERFORMANCES IN DUAL TASKS IN OLDER ADULTS WITH CHRONIC NECK PAIN: A RANDOMIZED CONTROLLED CLINICAL TRIAL

Abstract

Aim: There is limited information on dual-task performance in older individuals with chronic neck pain. This study aims to investigate cognitive and motor performances during dual tasks in older adults with chronic neck pain.

Methods: Thirty-five older adults with chronic neck pain and 35 older adults without neck pain were included in the study. The timed up and go test evaluated individuals' single-task performance. To assess the dual-task performances of the groups, the individuals were given motor and cognitive (forward and backward digit span) tasks simultaneously with the timed up and go test. During cognitive dual-task, the cognitive performances of individuals were evaluated and the duration of their timed up and go test was recorded.

Results: There was no difference between the groups in terms of single-task timed up and go test ($p > 0.05$). There was also no difference between the groups in terms of cognitive-forward and cognitive-backward ($p > 0.05$). However, cognitive performance of the chronic neck pain group during dual-task was worse than that of the control group ($p < 0.05$). Additionally, the motor dual-task of older adults in the chronic neck pain group was worse than the control group ($p < 0.05$).

Conclusion: Older adults with chronic neck pain struggle more in motor dual-task situations than asymptomatic older adults. Therefore, gait assessment with a motor dual task should be performed for older adults with chronic neck pain. In addition, during cognitive dual-task conditions, the cognitive performance of older adults should be evaluated in addition to their gait performance.

Keywords: Aged; Gait; Neck Pain; Postural Balance; Task Performance and Analysis.

INTRODUCTION

Neck pain is a common issue that often accompanies aging, and it is the second most common musculoskeletal problem (1,2). Its prevalence has been reported to be between 20–34.4% (3,4). Damage to structures such as ligaments, muscles, joints, discs, and neuromuscular junctions in the neck can cause neck pain. Additionally, degeneration and functional changes in these structures due to aging can cause pain. Approximately 50–85% of individuals with neck pain do not fully recover and can develop chronic neck pain (CNP) (5). CNP can limit daily activities and reduce quality of life by affecting upper extremity function. Furthermore, afferent proprioceptive input from cervical muscles, along with vestibular and visual inputs, is transmitted to the central nervous system to maintain postural control. Abnormal cervical afferent input in individuals with CNP can lead to impaired postural orientation and balance (6).

Functional balance is usually assessed with static and dynamic tests, such as the Romberg test, single leg stance test, or timed up and go (TUG) test. However, single tasks are rarely performed in daily life. Movements are often performed as dual or triple tasks. Therefore, attention is important in addition to the systems that maintain balance and central nervous system orientation (7). To evaluate dual-task (DT) performance, cognitive or motor tasks are often added to gait tasks, creating a simulation of real-life situations. Performance in DT situations is known to decrease compared to single tasks, referred to as the DT effect (8). DT performance provides important information in attention, as well as balance and risk of falling. Therefore, when evaluating tasks, both the basic motor and the performance of the cognitive tasks given should be assessed.

Although there are various approaches to explaining and classifying attention processes, there is no complete consensus on these classifications. The classifications generally focused on alertness/arousal, selective attention, sustained attention (wakefulness), and divided attention. (9). Performance reduction during DT is mainly associated with divided attention (9).

Several studies have investigated single or DT performance in individuals with CNP, but there is no consensus on the findings (1,10-12). To our knowledge, no study in the literature has investigated cognitive and motor performance simultaneously during dual-task situations in older individuals with CNP.

This study aimed to investigate cognitive and motor performance during dual-task situations in older individuals with chronic neck pain. According to our hypothesis, neck pain, which is directly related to abnormal proprioceptive inputs, may affect motor performance, or older individuals may allocate more cognitive capacity to compensate for this loss of motor performance.

MATERIALS AND METHODS

Ethical Situation

Written and verbal consent was obtained from all participants included in the study. Permission was obtained from the non-interventional ethics committee of the university to perform the study (Ethics no: 2023/1287). In addition, institutional approval was obtained from the hospital where the study was carried out (issue no: E-34771223-774.99-214732932).

Study Design and Participants

GPower 3.1 software was used to calculate the sample size in this prospective randomized control study. With an effect size of 1.01, a power of 95%, and a significance level of 0.05, a total sample size of 46 was required for the study (1).

Thirty-five older individuals with CNP (CNP group) and 35 older individuals without neck pain (control group) who applied to the outpatient neurosurgery clinic were included in the study. Detailed anamnesis was taken from these individuals. Individuals with CNP were selected according to the examination and magnetic resonance imaging results of patients who had neck pain due to straightening of the cervical lordosis or the onset of cervical disk herniation for at least three months and did not require surgery. The imbalance and fall status of the individuals were questioned, and the neck disability index (NDI) of the subjects was calculated. Participants were excluded if they had a traumatic neck injury/surgery, vestibular diseases, such as BPPV and Meniere's disease, neurological and uncontrollable systemic disease, visual impairment, cognitive impairment [Standardized Mini Mental Exam: SMME <24 (13)], and musculoskeletal injury/diseases that may affect gait.

Neck Disability Index

The NDI, adapted and assessed for validity and reliability in the Turkish context by Kesiktas et al. (14), consists of 10 questions. Individuals can score each question between 0 and 5. Notably, the disability increases as the total index score increases.

Visual Analogue Scale

Individuals' imbalances were assessed using the visual analogue scale (VAS). A straight line, 10 cm in length, was drawn on a piece of paper, with 0 representing "no imbalance" and 10 representing "very severe imbalance." Participants were instructed to mark the point on the line corresponding to the severity of their imbalance, and the imbalance score was determined by measuring this point with a ruler.

Time Up and Go Test

The main task used in our study was the TUG test. Participants were seated in a chair at the starting point of a 3-meter track and were given the command to "stand up, walk as quickly as possible along the track, and sit back down in the chair." The time taken by each participant to complete the task was measured using a stopwatch.

Digit Span Test

The visual-aural digit span test, a subtest of the Wechsler Memory Scale-Revised, whose Turkish validity and reliability (confidence correlation coefficients .38-.87) study was conducted by Karakas et al. (15) is part of a large neuropsychological test battery (16). The visual-aural digit span test consists of four subtests that evaluate verbal and written responses to aurally or visually presented number sequences. In our study, only the computer-generated visual-aural digit span test was applied to assign additional cognitive tasks to individuals. Although the computer-generated digit span test does not have novmative values in elderly individuals, it facilitates the application of the test. In addition, it was stated that the computerized form of the test increased the test-retest score (17). The computer-generated digit span test was used instead of the classical digit span test in our study because the problem of holding a pencil (fine motor) and hypermetropia is common in elderly individuals. On the other hand, the computer-generated visual-aural digit span test can be adjusted in figure size and applied to elderly individuals more quickly. In addition, the computer-generated digit span test is frequently used in dual-task research due to its ease of application (18). The reason for applying only the visual-aural digit span test is that hearing loss may occur in elderly individuals, and hearing loss may affect auditory digit span test results.

The digit span test, which evaluates attention and short-term memory, was applied as forward-digit span and backward-digit span tasks as stated by Powell and Hiatt (19). The number strings were visually presented using PowerPoint on a 17-inch monitor with a resolution of 144 points. The number sequences ranged from 2 to 9. Participants were informed about the application of the test. The test began with a triple number sequence, and the number of sequences increased by one when the individual correctly repeated the numbers. A binary number sequence was applied if the individual could not repeat the triple number sequence correctly. If the participant could not repeat the number sequence, another number sequence of the same length was presented. If the participant could not repeat the second number sequence, the test was terminated, and the number sequence threshold was determined. First, the forward digit span test was completed and then the barkward digit test was applied. For the backward digit span task, the participants were asked to repeat the number sequences presented on the computer screen in reverse order using the same method. Thus, the forward and backward digit span thresholds (maximum number of digits with correct answers) of each participant were determined.

Dual-Task Performance

Secondary cognitive and motor tasks were added to the main task (TUG) to assess dual-task performance. The TUG and digit span tests were performed simultaneously as additional cognitive tasks. Participants were presented with a number sequence at their digit span threshold and were asked to say the sequence after completing the TUG. The time it took for participants to complete the TUG with the additional cognitive task ($TUG_{forward}$ and $TUG_{backward}$) was measured and recorded using a stopwatch. Additionally, the participants' digit span performance during the dual task was recorded as either "correct repetition" or "false repetition."

To evaluate the individuals' motor performance during the TUG, they were asked to carry a glass of water on a tray while completing the task (TUG_{motor}). Participants were asked to walk quickly on a three-meter line and hold the tray with both hands. The completion time of the TUG task for each participant was measured with a stopwatch and recorded.

The following formula was used to evaluate dual-task cost (DTC) for each participant (20).

$$\frac{\pm(\text{Single Task - Dual Task})}{\text{Dual Task}} \times 100 = \%\text{DTC}$$

Statistical Analysis

Statistical analysis was performed using IBM SPSS 21 software. The normality of the data distribution was checked using the Shapiro–Wilk test. Normally distributed data were presented as mean ± standard deviation (sd), while non-normally distributed data were presented as median (minimum–maximum). To compare the numerical data between the two groups, the independent simple t-test was used when the normality assumption was met, and the Mann–Whitney U test was used when it was not. Categorical variables were evaluated using the chi-square test. A p-value of less than 0.05 was considered statistically significant in all analyses.

RESULTS

Of older adults in the CNP group, 24 (68.6%) were female, 11 (31.4%) were male, and the mean age was 70.11 ± 4.59 (65-81). Eighteen (51.4%) of the older adults in the control group were female, 17 (48.6%) were male, and the mean age was 72.25 ± 6.10 (65-84). There was no difference between the groups in terms of age and gender (p=0.192, 0.143, respectively).

Of the individuals in the CNP group, 19 (54.3%) were primary school graduates, 12 (34.3%) were secondary school graduates, 3 (8.6%) were high school graduates, and 1 (2.9%) were university graduates. Of the individuals in the control group, 15 (42.9%) were primary school graduates, 14 (0.4%) were secondary school graduates, 5 (14.3%) were high school graduates, and 1 (2.9%) were university graduates. There was no difference between the groups in terms of educational status (p=0.771).

Table 1. Fall, imbalance (VAS) and single-task TUG scores by groups.

	CNP Group Median (min-max) n:35	**Control Group** Median (min-max) n:35	**p**
Single-Task TUG (sec)	10.19 (7.19-18.77)	9.28 (6.62-16.30)	0.366[a]
VAS	2.00 (0-10)	1.00 (0-7)	0.351[a]
Falls (n)	11 (31.4%)	5 (14.3%)	0.088[b]

TUG: Time up and go test, VAS: Visual Analogue Scale, a: Mann Whitney-U test, b: Chi Suare Test

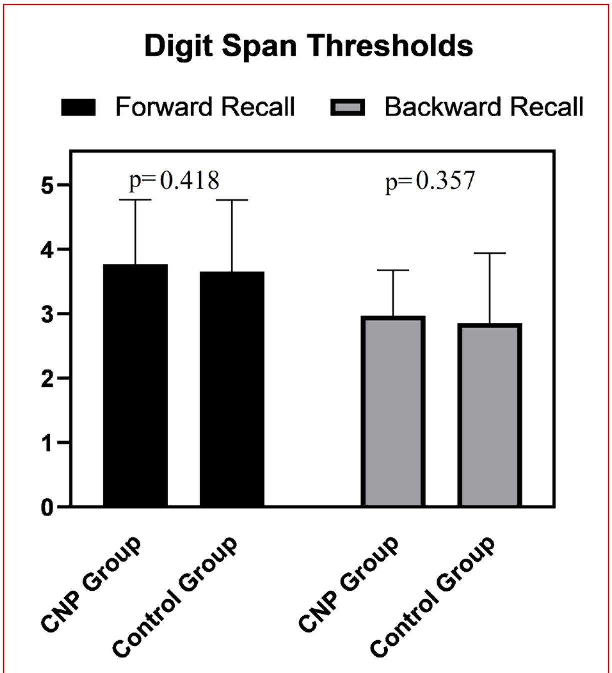

Figure 1. Forward and backward digit span thresholds by groups.

The median value for neck pain duration in the CNP group was 12 months (range: 3–240), and the median value for the NDI was 23 (range: 12–38). There was no significant correlation between neck pain duration and NDI score (p=0.846). Although the older adults in the CNP group had a higher incidence of falls than those in the control group (OR: 2.750), there was no significant difference between the two groups (p >0.05). Similarly, there was no difference between the two groups in terms of VAS and single-task TUG (p >.05). Table 1 shows the fall, imbalance, and single-task TUG scores for both groups.

There was no significant difference between the two groups in terms of forward and backward digit span thresholds (maximum number of digits with correct answers) (p >0.05, as shown in Figure 1). Similarly, there was no difference between the two groups in terms of $TUG_{forward}$ and $TUG_{backward}$ durations (p >0.05). However, the CNP group had a longer TUG_{motor} duration compared to the control group (p <0.05). Table 2 presents the $TUG_{forward}$, $TUG_{backward}$, and TUG_{motor} durations and DTCs for both groups.

Regarding the digit span success of the groups during the dual task, older adults in the CNP group had a significantly lower success rate than those in the control group in both forward digit span (OR: 3.244) and backward digit span (OR: 2.875) (p <0.05). Figure 2 presents the forward and backward digit span results for both groups during the dual task.

The mean of forward digit span thresholds of the participants in the CNP group was 3.77±1.00 and the mean of backward digit span thresholds was 2.97±0.70. Participants in the CNP group had more difficulty in the backward digit span test (p<0.001). Looking at the backward and forward digit span performances during the dual task in the

Table 2. $TUG_{forward}$, $TUG_{backward}$ and TUG_{motor} durations and dual task costs by groups.

	CNP Group Median (min-max) n:35	**Control Group** Median (min-max) n:35	**p***
$TUG_{forward}$ (sec)	9.76 (7.31-19.61)	9.20 (6.70-16.39)	0.259
DTC (%)	0.47%	1.80%	
$TUG_{backward}$ (sec)	10.23 (7.35-18.29)	9.92±2.40	0.259
DTC (%)	0.37%	2.41%	
TUG_{motor} (sec)	11.35 (9.10-23.58)	10.43±2.72	0.006
DTC (%)	14.83%	2.58%	

Mann Whitney-U test, TUG: Time up and go test, DTC: Dual-task cost

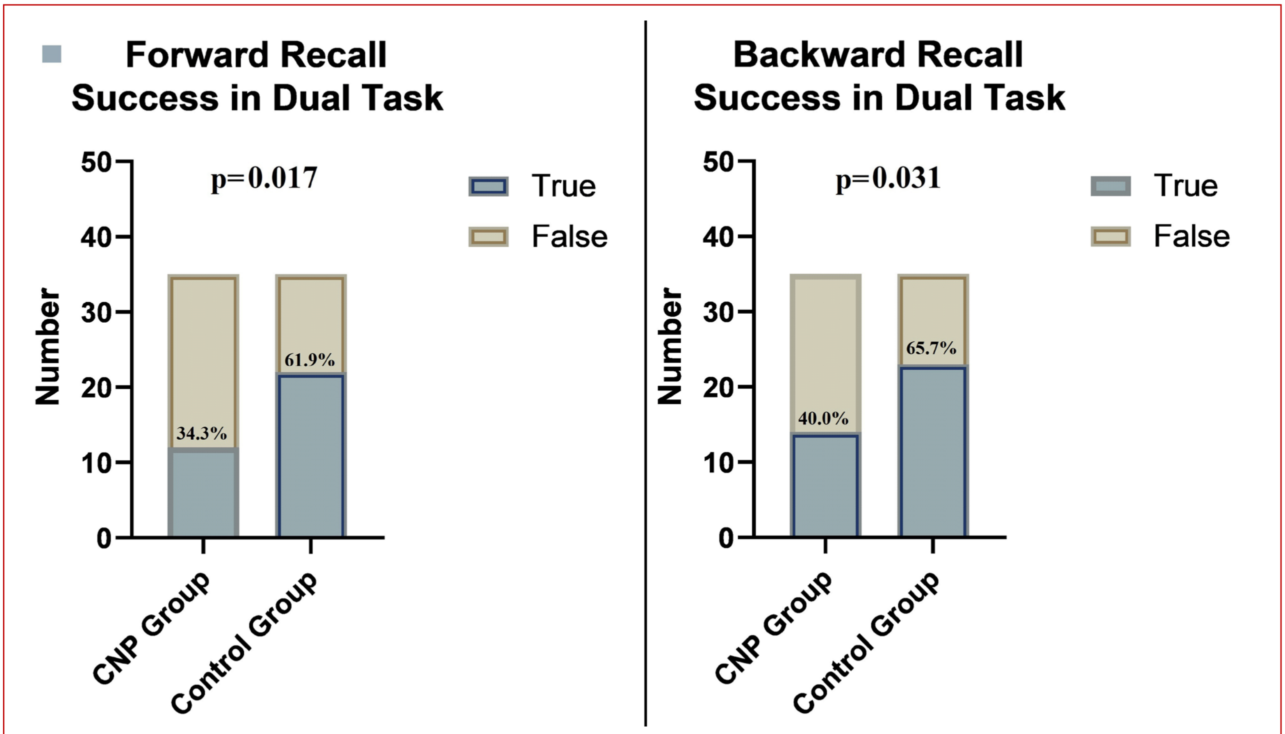

Figure 2. Forward and backward digit span results during dual-task by groups.

CNP group, the backward success of the individuals was 14 (40%) correct and the forward success was 12 (34.3%) correct. There was no difference in the backward and forward digit span performances in the CNP group (p=0.621).

DISCUSSION

Although vestibular disorders are often believed to be the primary cause of imbalance, multisensor dizziness is also prevalent, particularly in older adults. It is considered the second most common disorder after benign positional paroxysmal vertigo (21). Multisensor dizziness refers to a decline in balance systems due to aging. Further, aging may exacerbate the impact of abnormal somatic afferent information from the upper cervical region in older adults with CNP. As a result, walking, which is the most crucial balance parameter, may be more affected in these individuals (22). Therefore, our study aimed to investigate the cognitive and motor performances of older adults with CNP during dual tasks. Specifically, we aimed to identify any changes in attention and cognitive capacity that occur during walking in older adults with CNP. Our results showed no significant differences in the duration of single-task TUG, $TUG_{forward}$, and $TUG_{backward}$ (TUG with dual task) between the CNP and control groups. However, we observed that the cognitive performance of older adults with CNP during dual tasks was worse than that of older adults in the control group, although the TUG duration remained unchanged. Similarly, the TUG_{motor} duration of older adults with CNP was worse than that of individuals in the control group.

Studies investigating dual-task performance in older adults individuals have reported that during dual tasks, the stride length and speed of older adults change, and these gait changes are associated with an increased risk of falling (10,23). Safe walking ability is crucial for mobility and independence in old age, providing social participation, increasing self-confidence, and preventing falls. Therefore, the ability to perform dual tasks can determine the risk of falling, and dual-task exercises can help reduce this risk (8).

Only a few studies have investigated walking speed during dual-task performance in older adults with CNP (24). Poole et al. (24) examined walking speed with (dual task) and without head rotation (single task) in older adults with CNP using a 10-meter walking test. The authors reported that older adults with CNP had a longer gait cycle and that older adults with CNP preferred a slower self-selected gait speed in head rotation walking. The authors suggested that the impairment in gait may be due to the dual-task effect or the change in cervical somatosensory input caused by fear of pain or pain during neck rotation.

Other studies investigating DT in individuals with CNP have been performed on adult populations (1,11,12). Saadat et al. (1) evaluated walking speed in adults with CNP under three conditions: basic TUG, TUG with an easy cognitive task, and TUG with a difficult cognitive task. The authors reported that individuals with CNP exhibited a decrease in walking speed in all conditions, and the duration of TUG was prolonged as the cognitive task became more difficult. Kirmizi et al. (11) evaluated the balance skills of 22 adult women with CNP under different sensory and dual-task conditions. The authors applied tests with eyes open and closed using four different methods: standing silently, head rotation, counting backwards, and standing on a foam pad. The authors reported that the balance skills of women with CNP were impaired, especially in head rotation with eyes open and counting backwards. Patients with CNP exhibited worse balance performance in different sensory and dual-task conditions. Sremakaew et al. (12) evaluated the walking speed of 30 adults with CNP under four different conditions: comfortable walking, single-task tandem gait, cognitive dual-task gait, and motor dual-task gait. In contrast to Saadat et al. (1) and Kirmizi et al. (11), the authors found that the DT performance of individuals with CNP was not affected and that they only performed worse on the single-task tandem gait test. Therefore, the authors concluded that the effect of neck pain on walking speed is not related to attention but may be due to biomechanical limitations. Unlike these studies, we assessed both walking speed and cognitive performance during dual-task situations in older adults with CNP. In the present study, we found no difference in the duration of single-task TUG and cognitive dual-task TUG ($TUG_{forward}$ and

$TUG_{backward}$) between older adults with CNP and asymptomatic older adults. However, the cognitive performance and TUG_{motor} duration of older adults with CNP during dual tasks were worse than those in the control group.

In the tandem walking test, one foot is placed toe-to-heel with the other foot and walked in a straight line, making it more challenging than regular walking. In our study, we used the single-task TUG test, which is similar to a comfortable gait, as noted by Sremakaew et al. (12). Therefore, abnormal somatosensory inputs caused by neck pain, which can impair postural control, may not have affected the performance of the single-task TUG. However, according to the cross-competition model, tasks of the same type require the same cognitive skills, leading to competition between tasks (25). Simultaneously performing similar tasks may cause further performance degradation in the tasks. Further, as Moreira et al. (26) suggested, abnormal somatosensory inputs from the neck may impair neck image and decrease neck awareness, further affecting motor performance during TUG in older adults with CNP. Therefore, the difficulty in carrying a glass filled with water on a tray while performing TUG in our study may be due to impaired multisensor balance interaction and decreased neck awareness in older adults with CNP.

A study demonstrated that balance evaluation system test scores deteriorated during normal aging and decreased even more in older adults with CNP (27). Our study revealed no difference in the subjective perception of imbalance between older adults with CNP and asymptomatic older adults. However, although not statistically significant, we found that older adults with CNP experienced approximately three times more falls than asymptomatic older adults. The reason why older adults with CNP fell more frequently may be because the motor task of walking performance in these individuals was more impaired. Consequently, similar types of motor tasks may increase the likelihood of falling during walking for older adults with CNP.

Humans have limited processing capacity, and cognitive ability is allocated to tasks in multitasking (28). Therefore, it is more challenging to perform multiple tasks simultaneously than to perform single tasks (29). In our study, similar to Sremakaew's study (12), there was no significant difference between the groups in terms of $TUG_{forward}$ and $TUG_{backward}$ durations during DT. However, the cognitive performance of older adults with CNP during DT was worse than that of older adults in the control group. This can be explained by the serial bottleneck model, which suggests that attention is selective and tasks occurring in a particular order are not independent (25). The completion of one task may affect another. In our study, we asked individuals to remember numbers (digit spans) and say them after completing the TUG. Therefore, older adults with CNP may have shared their cognitive resources with the primary motor task with which they had more difficulty, and this may have affected their cognitive performance later on.

In our study, the backward digit thresholds of the participants in the CNP group were worse than the forward digit thresholds. However, there was no difference in these individuals' backward and forward digit span performances during the dual task. This situation can be explained by the dual-task methodology we applied. We applied the digit span test on the digit thresholds in the dual task. In addition, we asked individuals for digit span answers after TUG. The fact that the application of TUG saves time for the participants and the digit threshold of backward application is lower may have eliminated the backward-forward difficulty and may have brought the difficulty level of the two tests closer to each other.

When investigating DT performance, the method typically focuses on walking performance. However, this approach can be misleading because individuals may prioritize different tasks during DT. They may allocate more processing capacity to one task and care less about the other. Therefore, evaluating motor and cognitive performance during DT is important. Measuring cognitive performance, in addition to motor performance, can provide valuable information about attention sharing.

This study has some limitations. Typically, in the digit span task, the individual is asked to say the number sequences immediately at the end of the test. However, our study applied the digit span test with the TUG when evaluating the dual-task performance. As a result, there was a delay. This delay may have activated specific memory processes. Therefore, digit span test results applied with TUG may not reflect attention and short-term memory values in elderly individuals. The single-digit span test should be considered for attention and short-term memory. In addition, older adults may develop cognitive impairment due to depression, and depression can make the elderly more perceiving pain or suffering. In our study, the depression level of elderly individuals was not evaluated. In future studies, the effect of depression on dual-task and attention processes in elderly individuals can be investigated.

CONCLUSION

Our findings show that older adults with CNP have more difficulty in dual-task situations, such as walking while carrying a tray with glasses, compared to asymptomatic older adults. Since most daily activities involve performing multiple tasks simultaneously, gait assessment of older adults with CNP should include motor dual-tasking. When evaluating cognitive dual-tasking, relying solely on walking performance may yield misleading results. Therefore, assessing cognitive performance in addition to walking performance can provide crucial insights into the processing capacity of older adults with CNP.

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