The Journal of Physical Therapy Science

SPTS

Original Article

Effects of cognitive tasks on center-of-foot pressure displacements and brain activity during single leg stance: comparison in community-dwelling healthy older and young people

Kentaro Sasaki, RPT, PhD[1)*], Takafumi Ooi, RPT[2)], Ayako Yokota, RPT, MSc[3)],
Toshiki Azuma, RPT, MSc[4)], Keisuke Asano, RPT, MSc[5)], Shinichi Ooizumi, RPT, MSc[2)],
Tsuyoshi Kimura, PhD[6)]

[1)] Graduate School of Health Sciences, Kinjo University: 1200 Kasama, Hakusan city, Ishikawa
 924-8511, Japan
[2)] Department of Medical Technology Rehabilitation Center, Kaga Medical Center, Japan
[3)] Department of Physical Therapy, Kinjo University, Japan
[4)] Department of Rehabilitation, Yawata Medical Center, Japan
[5)] Department of Physical Therapy, Keiju Kanazawa Hospital, Japan
[6)] Department of Social Welfare, Faculty of Social Welfare, Kinjo University, Japan

Abstract. [Purpose] This study aimed to investigate the effect of cognitive tasks on the center-of-foot pressure (COP) displacements and brain activity during single leg stance (SLS) in older people. [Participants and Methods] This study included 25 healthy older (age, 68.8 ± 4.9 years) and 25 young (age, 21.0 ± 0.9 years) participants. Participants performed SLS for 35 s under a single-task (ST) and three dual-tasks (DTs), namely verbal, subtraction, and recall tasks. We measured the total length of COP (COP_{TL}) and change in oxygenated hemoglobin (HbO_2) levels during SLS under four tasks. [Results] There were no differences in COP_{TL} and HbO_2 levels in the young group, whereas COP_{TL} in the recall task was significantly longer than in ST in the older group. In the comparisons of the DTc (the relative change of DT to ST), no differences were found among three DTs in the young group, whereas the DTc of COP_{TL} in the recall task was significantly higher than that in the verbal task in the older group. Regarding HbO_2, no differences were observed among the four tasks in both groups. [Conclusion] These results suggest that SLS combined with a recall task may be useful for fall risk screening in healthy older individuals.
Key words: Single leg stance with a cognitive task, Center-of-foot pressure displacement, Oxygenated hemoglobin level

(This article was submitted Sep. 9, 2021, and was accepted Dec. 2, 2021)

INTRODUCTION

Falls and subsequently fractures are one of the serious problems that impede healthy life of older people. Hence, fall-risk screening has been conducted for community-dwelling older to reduce the incident of falls.

In our daily life, we process a large amount of information obtained outside the body, such as ground surface conditions, people around us, and traffic, while simultaneously control the body to adapt to the surrounding environment. In other words, our activities involve continuous multitasking. To perform multiple tasks, it is necessary to allocate attention resources appropriately inside and outside the body and change their distribution according to the situation. However, when performing

*Corresponding author. Kentaro Sasaki (E-mail: kany-s@kinjo.ac.jp)

highly difficult multiple tasks beyond our attentional capacity, we experience cognitive-motor interference, which lowers one or both of the cognitive and motor processing skills[1]. A reduced ability to process motor and cognitive tasks at the same time is reported to be strongly associated with an increased risk of falls in elderly people[2]. Therefore, when conducting a fall risk screening, the use of a dual-task (DT) consisting of motor and cognitive activities is more appropriate than the use of a single-task (ST). Because falls usually occur while on the move, gait is often selected as a motor task in DT fall risk screening. It has been shown that DT consisting of gait performance combined with a cognitive task can better predict falls in community-dwelling older people than using gait performance alone as a single motor task[3]. However, walking requires an adequate space, and measurements may not be possible outdoors depending on the weather condition.

Another motor task potentially useful for the DT fall risk screening is timed single leg stance (SLS)[4, 5]. Studies have shown that older people with a history of falls in the past one year have shorter SLS time than those without it[6] and that SLS time is an independent predictor of falls resulting in physical injury[7]. Since the SLS test does not require walking unlike gait velocity (time) measurement, it can be easily done in a limited space such as a community meeting center.

A previous study showed that older people exhibited shorter SLS times under a DT condition than younger did[8]. However, we could not find any published studies dealing with DT fall risk screening using SLS. Hence, to obtain basic data for the application of DT_SLS for the fall risk screening, we here examine the center-of-foot pressure (COP) displacements and brain activity during DT_SLS in community-dwelling older people from the standpoint of fall prevention. This study aimed to clarify the characteristics of posture control and brain activity in older people during DT_SLS and comparing them with the data of young people.

PARTICIPANTS AND METHODS

The participants were 25 community-dwelling older people (13 females and 12 males, 68.8 ± 4.9 years) and 25 healthy young people (13 females and 12 males, 21.0 ± 0.9 years). Eligibility criteria were as follows: 1) no subjective symptoms related to locomotive organs; 2) being able to maintain SLS for 35 sec on either leg; 3) having normal cognitive function (Mini Mental State Examination [MMSE] score of 24 or higher); 4) not applicable to 'Sarcopenia' specified by the Asia Working Group for Sarcopenia in 2019[9] and 5) living independently at home. We identified people who met 1) to 5) in the older group and those who met 1) and 2) in the young group by interviewing, measuring, and verifying. Prior to the start of the study, the study outline was explained using relevant documents to the participants, who signed the consent form upon full understanding of the information provided. This study was conducted with approval of the research ethics committee of Kinjo University (Approval No. 2019-03).

Force plates (BP400600HF-2000, AMTI, Watertown, MA, USA) were used to measure COP displacements. The participant stood on two force plates arranged side by side, one under each foot, with the legs hip-width apart to assume the two-leg standing position. The examiner instructed the participant to cross the arms on the chest and stare at a black mark measuring 3 cm in diameter (at the participant's eye level) on a whiteboard placed 2 m ahead. Upon the examiner's cue, the participant raised the one leg near-vertically, approximately 10 cm off the ground. After 35 sec from the start, the participant returned to the two-leg standing position with the examiner's cue. The sampling frequency of the force plate was set at 100 Hz. The test leg was the non-dominant leg, which has a higher support function[10] (the leg contralateral to the throwing arm in pitching).

For brain activity during SLS, a head-mount type near-infrared spectroscopy (NIRS) (PocketNIRS HM, DynaSense, Hamamatsu, Japan) was placed on the participant's forehead to measure changes in oxygenated hemoglobin (HbO_2) levels in both sides of the prefrontal cortex (PFC). The HbO_2 measured by NIRS is known as an indicator reflecting brain activity in gait adjustments[11]. The HbO_2 levels in the PFC increase during DT in both young and older people[12], and HbO_2 levels in the PFC increase with increasing task difficulty in young people[13]. NIRS measures HbO_2 levels by emitting continuous light using LED light source at three different wavelengths (735 ± 15 nm, 810 ± 18 nm, 850 ± 20 nm). The device uses a photodiode light detector and has two channels, one on each side. The source-detector distance is fixed at 3 cm. NIRS uses constant light for measurement, and the optical pathlength from the irradiation to the reception of near-infrared light is unknown. Therefore, measured HbO_2 is calculated as the amount of change from the value in the baseline resting sitting position. The sampling frequency of the NIRS was set at 20 Hz. As for the irradiation sites, we followed the international 10–20 system of electroencephalogram electrode placement to identify the frontal pole (fp) corresponding to the prefrontal area[14] and attached the device to the forehead. After the placement of NIRS, the device and participant's head were covered with a shower cap to prevent shifting so that ambient light would not interfere with the light detector. The participant remained in a two-leg stance for 30 sec before performing SLS.

We set up four tasks as the conditions for performing SLS. The four tasks were as follows: SLS with no cognitive task (ST); DT_SLS with a verbal task to count numbers from 1; DT_SLS with a subtraction task to perform serial-3 subtractions from a predefined 3-digit number shown by the examiner; and DT_SLS with a recall task to recall an item that belongs to a certain category [such as fruits or vegetables] presented by the examiner. For the verbal task, the participants were instructed to maintain their own pace and avoid counting too fast or too slow. For the subtraction task, the participants were instructed to perform as many serial subtractions as possible while trying not to make mistakes. For the recall task, the participants were instructed to give as many answers as possible without using the same words twice. As for the timing to start each task, the verbal task was started about 3 sec after the start of SLS, while the subtraction and recall tasks were given by the examiner

J. Phys. Ther. Sci. Vol. 34, No. 3, 2022

178

about 3 sec after the start of SLS. For the three DT tasks, the participants were instructed to use a conversational tone of voice to answer. The subtraction and recall tasks were recorded using a voice recorder, and the numbers of correct/wrong answers were checked after measurements. The tasks were performed by each participant in an order predetermined by random draw. The participants were instructed to avoid saying anything other than the answers during SLS and continue staring at the mark. When SLS could not be maintained for 35 sec, the task was considered failed and moved to the last. The participant then proceeded to perform the next task.

The time to SLS stabilization was estimated to be 5 sec. Therefore, the first 5 sec of data were deleted, and the remaining 30 sec of data were used for analysis. Regarding COP displacements, the total COP trajectory length during the 30 sec (COP_Total Length: $COP_{\_TL}$) and the standard deviation of the variability in COP velocity every 0.01 sec (COP_velocity SD: COP_v_{SD}) were calculated based on the continuous data recording from the force plates for each of the four tasks. Regarding HbO_2, mean values of HbO_2 in brain activity opposite to SLS support leg ($HbO_2\_$support: HbO_2_sup) and HbO_2 in the brain activity opposite to SLS elevated leg ($HbO_2\_$elevation: HbO_2_elev) during the 30 sec were calculated.

Dual-task cost (DTc) is used as an indicator of cognitive-motor interference under a DT condition[15]. DTc is expressed as a percentage calculated as (DT value−ST value)/ST value ×100. In this study, however, there were participants whose mean HbO_2 during the 30 sec of ST was lower than in a resting sitting position; some even had negative HbO_2 values in ST. In such cases, DTc expressed as a percentage cannot adequately represent cognitive-motor interference; therefore, this study used DTc computed by subtracting the mean value during the 30 sec of ST from the mean value during the 30 sec of each DT.

In statistical investigation, we first compared HbO_2_sup and HbO_2_elev in ST with those during the two-leg stance to demonstrate that performing SLS alone requires appropriate attention resources even in older and young who are physically and mentally healthy. Comparisons were made using paired t-test if the results of Shapiro-Wilk test showed normally distributed data in both groups; otherwise, Wilcoxon signed-rank test was used.

Next, we performed two-way analysis of variance to examine whether differences were seen in $COP_{\_TL}$, COP_v_{SD}, HbO_2_sup, and HbO_2_elev between the generations (older and young) and among the elements of each task. Tukey test was used to compare COP and HbO_2 among the four tasks if the results of Shapiro-Wilk test showed normally distributed data in all the tasks to be compared; otherwise, Steel-Dwass test was performed.

To compare the degree of cognitive-motor interference in the three DT tasks, Tukey test was used if the results of Shapiro-Wilk test performed on the DTc of $COP_{\_TL}$, COP_v_{SD}, $HbO_2\_sup,$ and HbO_2_elev showed normally distributed data in all the tasks to be compared; otherwise, the Steel-Dwass test was performed.

Regarding the subtraction and recall tasks, the percentage of correct answers was obtained based on the numbers of responses and correct answers, and comparisons were made between the tasks using Wilcoxon signed-rank test.

The statistical software IBM SPSS 26 and the R Project for Statistical Computing ('R') were used. The significance level was set at 5% for all analyses.

RESULTS

Regarding $COP_{\_TL}$/COP_v_{SD} and HbO_2_sup/HbO_2_elev, the measurements in the older group are shown in Table 1 and those in the young group in Table 2.

Compared to the values in the two-leg stance, HbO_2_sup and HbO_2_elev during ST were significantly higher in both young and older groups (p<0.001 in all the cases).

Two-way analysis of variance was used to examine the differences in variables between the generations and among the tasks. While differences were noted in all $COP_{\_TL}$ (p<0.001), COP_v_{SD} (p<0.05), HbO_2_sup (p<0.001), and HbO_2_elev (p<0.001) between the generations, no differences were observed among the tasks. Based on these results, the variables were compared within each generation. In the comparisons of the four SLS tasks, no differences were found in the young group, whereas $COP_{\_TL}$ in the recall task was significantly longer than in ST in the older group (p<0.01).

In the comparisons of the DTc among the tasks, no differences were found among the 3 DTs in the young group, whereas the DTc of $COP_{\_TL}$ in the recall task was significantly higher than in the verbal task in the older group (p<0.001). Although the difference was marginal, the DTc of COP_v_{SD} in the recall task also tended to be higher than in the verbal task (p=0.06). Regarding HbO_2, no differences were observed among the tasks in either group.

The percentage of correct answers was 96.9 ± 4.8% in the subtraction task and 99.1 ± 2.1% in the recall task in the young group, showing no significant difference. In older group, however, the percentage was 96.1 ± 4.9% in the subtraction task and 98.3 ± 4.6% in the recall task, with the latter being significantly higher (p<0.05).

DISCUSSION

The timed SLS alone is potentially useful for the fall risk screening in older pepople[6, 7]. It is well known that postural control requires some attention resources[16]. Compared to the levels during two-leg stance, HbO_2 was significantly elevated by maintaining SLS (ST) in not just the older group but in the young group as well. This study actually showed elevated levels of HbO_2 during SLS using NIRS, revealing that SLS, even without a cognitive task, is performed under a certain level

Table 1. The results of COP displacements and HbO_2 during two-leg stance and SLS under 4 conditions in older group

	Two-leg stance	ST	DT Verbal task	DT Subtraction task	DT Recall task
COP_{TL} (mm)[*1]	–	2,041.7 ± 627.3	2,131.5 ± 617.3	2,288.0 ± 534.0	2,460.0 ± 615.1
DTc@COP_{TL}[*2]	–	–	89.9 ± 248.2	246.3 ± 292.2	418.3 ± 302.3
COP_{VSD} (mm)	–	0.0486 ± 0.0210	0.0494 ± 0.0217	0.0490 ± 0.0111	0.0530 ± 0.0136
DTc@COP_{VSD} (mm)	–	–	0.0008 ± 0.0168	0.0004 ± 0.0137	0.0044 ± 0.0134
HbO_2_sup[*3]	−0.00904 ± 0.02672	0.07678 ± 0.06480	0.07684 ± 0.06120	0.07683 ± 0.07097	0.08224 ± 0.06597
DTc@HbO_2_sup	–	–	0.00006 ± 0.02015	0.00006 ± 0.02391	0.00546 ± 0.02652
HbO_2_elev[*4]	−0.00536 ± 0.02660	0.07693 ± 0.06235	0.07518 ± 0.07313	0.07878 ± 0.07819	0.08575 ± 0.07328
DTc@HbO_2_elev	–	–	−0.00176 ± 0.02505	0.00184 ± 0.02811	0.00882 ± 0.03075

Mean ± SD.
COP_{TL}: the total length of COP.
COP_{VSD}: the standard deviation of the variability in COP velocity every 0.01 sec.
HbO_2_sup: mean values of HbO_2 in brain activity opposite to SLS support leg.
HbO_2_elev: mean values of HbO_2 in brain activity opposite to SLS elevated leg.
*Negative values mean lower than sitting at rest.
DTc@COP: value calculated as DT value − ST value.
DTc@Hb: value calculated as DT value − ST value.
[*1] ST vs. recall: $p<0.05$.
[*2] verbal vs. recall: $p<0.05$.
[*3] two-leg stance vs. ST: $p<0.001$.
[*4] two-leg stance vs. ST: $p<0.001$.

Table 2. The results of COP displacements and HbO_2 during two-leg stance and SLS under 4 conditions in young group

	Two-leg stance	ST	DT Verbal task	DT Subtraction task	DT Recall task
COP_{TL} (mm)	–	1,454.9 ± 320.9	1,431.8 ± 268.2	1,495.2 ± 365.8	1,458.3 ± 324.5
DTc@COP_{TL}	–	–	−23.1 ± 208.2	40.3 ± 366.9	3.4 ± 341.0
COP_{VSD} (mm)	–	0.0308 ± 0.0077	0.0301 ± 0.0065	0.0322 ± 0.0098	0.0524 ± 0.1048
DTc@COP_{VSD} (mm)	–	–	−0.0007 ± 0.0050	0.0014 ± 0.0099	0.0216 ± 0.1064
HbO_2_sup[*5]	−0.00389 ± 0.01987	0.02991 ± 0.03968	0.03107 ± 0.03716	0.03553 ± 0.03584	0.03015 ± 0.04448
DTc@HbO_2_sup	–	–	0.00117 ± 0.02926	0.00562 ± 0.02405	0.00025 ± 0.05020
HbO_2_elev[*6]	−0.00320 ± 0.02341	0.03648 ± 0.04506	0.04031 ± 0.04774	0.04582 ± 0.04304	0.04290 ± 0.05012
DTc@HbO_2_elev	–	–	0.00384 ± 0.02420	0.00934 ± 0.02706	0.00642 ± 0.02735

Mean ± SD.
COP_{TL}: the total length of COP.
COP_{VSD}: the standard deviation of the variability in COP velocity every 0.01 sec.
HbO_2_sup: mean values of HbO_2 in brain activity opposite to SLS support leg.
HbO_2_elev: mean values of HbO_2 in brain activity opposite to SLS elevated leg.
*Negative values mean lower than sitting at rest.
DTc@COP: value calculated as DT value − ST value.
DTc@Hb: value calculated as DT value − ST value.
[*5] two-leg stance vs. ST: $p<0.001$.
[*6] two-leg stance vs. ST: $p<0.001$.

of attention control. Because increases were seen in both HbO_2_sup and HbO_2_elev, the elevated leg is considered to play a part in the control of COP displacements during SLS.

Our findings showed no significant changes in COP displacements or HbO_2 levels in the young group regardless of task types, whereas COP_{TL} and DTc of COP_{TL} in the recall task was significantly larger than the ST or verbal task in the older group. Furthermore, the DTc of COP_v_{SD} in the recall task tended to be higher than in the verbal task. The increase in these COP displacements reflect high fall risk, indicating that the risk of falling during SLS with a recall task is higher than during ST SLS. In a healthy older people sustaining both physical and cognitive functions in the real world, motor tasks have priority for the allocation of attention when the risk of falling is high, but cognitive tasks are prioritized in a situation where the person can maintain steady balance[2]. In the older group, the percentage of correct answers in the recall task was high at 98.3%. Based on this, it is inferred that the cognitive task was prioritized, resulting in an increase in COP_{TL}, a motor task

J. Phys. Ther. Sci. Vol. 34, No. 3, 2022

180

index. However, the older group showed no significant increase in HbO_2 in the recall task compared to the other tasks. A study that used NIRS to examine brain activity in gait performance as a DT motor task reported that adding a cognitive task led to elevated HbO_2[12]. This contradicts with the result of our study, which used SLS as a motor task. Although there is no past report on HbO_2 measured during DT_SLS, possible reasons why HbO_2 did not increase in our study may be that SLS is a static posture control while gait is a dynamic activity and that the measurements in our study were taken in a laboratory where no dynamic changes occurred in the surrounding environment, thereby not requiring as much attention resources or control as walking outdoors would. Moreover, the duration of SLS was only 35 sec, which may also be a reason why no change was seen in HbO_2.

To summarize the results in the older group, there were no differences in brain activity (HbO_2) among the tasks, and sway in the center of gravity ($COP_{\_TL}$) was high in the recall task. The hypothesis at the beginning of the study was that the subtraction task would have the highest cognitive-motor interference, as well as the greatest COP displacements and HbO_2 changes. The recall task is a cognitive task requiring nothing more than recalling an item belonging to the category presented, whereas the subtraction task requires performing a subtraction and memorizing the answer to perform the next subtraction. In other words, the subtraction task is to maintain SLS while performing two cognitive processes, subtraction and memorization, simultaneously. For that reason, the degree of difficulty was assumed to be higher than that of the recall task. The percentage of correct answers in the older group was slightly significantly lower in the subtraction task than in the recall task. However, contrary to our hypothesis, both groups showed no difference in COP displacements or HbO_2 changes in the subtraction task than in ST. Since both groups had elevated HbO_2 during SLS compared to HbO_2 during the two-leg stance, the type and difficulty of the tasks and SLS duration may have been insufficient to observe further elevation in HbO_2. On the other hand, in the older group, only $COP_{\_TL}$ in the recall task was significantly longer than in ST, even though it was less difficult than the subtraction task. The postural sway would increase or decrease depending on the complexity of adding cognitive task. When performing high demanding cognitive task during DT, older adults tend to increase co-contraction of leg muscles[17, 18]. The co-contraction of the agonist and antagonist muscles is known to be enhanced more in older people than in young people due to age-related attenuation of cortical reciprocal inhibition[19]. In older people, increased difficulty of a cognitive task or concentrating on the cognitive task under DT condition may promote co-contraction of the lower limb skeletal muscles, possibly reducing postural sway[18]. In summary, it was assumed that the increase in co-contraction of the lower limb skeletal muscles, which helps stabilize SLS, was enhanced by adding the subtraction task, a cognitive task of higher difficulty, consequently increasing stiffening of leg joints and preventing an excessive increase in COP displacements. To verify this assumption, a future study needs to measure the muscle activity and strength of simultaneous muscle contractions in the lower limb skeletal muscles using surface electromyography and examine the differences among the tasks.

This study included a verbal task with a low cognitive load. The initial hypothesis of the study was that comparisons between ST and DT subtraction/recall tasks would find greater COP displacements and brain activity in the latter due to the higher cognitive loads. However, unlike the subtraction/recall tasks, ST does not involve speaking. To prove the hypothesis, it was necessary to rule out the possibility that the act of speaking itself may affect COP displacements and brain activity. That is why we included the verbal task of counting numbers, which is an extremely low cognitive element, to compare with the other tasks. As a result, both the older and young groups showed no differences between ST and the verbal task. In the older group, $COP_{\_TL}$ was significantly greater in the recall task than in ST, and the DTc of $COP_{\_TL}$ was significantly higher in the recall task than in the verbal task. These results indicate that the high COP displacement value in the recall task was not caused by the act of speaking, proving the hypothesis that it was due to cognitive-motor interference caused by the addition of the cognitive task (the act of recall).

This study has several limitations. First, NIRS was carefully placed by identifying the irradiation sites according to the international 10–20 system of electroencephalogram electrode placement, but there was no way to confirm which area of the brain the measurements were taken without the use of MRI or any other such device. For that reason, we could not determine how much of the PFC activity was reflected in the obtained data. Additionally, measurements were taken on only one leg in consideration of the participants' fatigue. Therefore, we could not look into differences in control between the dominant and non-dominant legs or the characteristics of the functional localization in the left and right hemispheres. Furthermore, the duration of measurement was set to 35 sec in consideration of the participants' abilities and fatigue, but it may have been too short. In particular, this study found no difference in HbO_2 levels among the tasks, and it is possible that the duration of measurement was too short to detect changes in HbO_2. The characteristics of each task could have been better understood if the duration were longer. Further studies should be conducted to address these limitations.

The results of this study showed that COP displacements increase in community-dwelling older people by adding a recall task to SLS. This result suggests that SLS with a recall task would be useful for the fall risk screening in older people. However, we could not determine whether SLS with a recall task was superior to SLS alone for fall risk screening based on the findings of the present study. All participants in older group were not applicable to 'Sarcopenia' and lived independently in their community. For this reason, SLS with a recall task would be difficult for frail older individuals to perform. Therefore, we need to prospectively examine the power of SLS with a recall task in fall prediction for physically and mentally healthy older individuals.

REFERENCES

1) Snijders AH, Verstappen CC, Munneke M, et al.: Assessing the interplay between cognition and gait in the clinical setting. J Neural Transm (Vienna), 2007, 114: 1315–1321. [Medline] [CrossRef]

2) Yogev-Seligmann G, Hausdorff JM, Giladi N: The role of executive function and attention in gait. Mov Disord, 2008, 23: 329–342, quiz 472. [Medline] [Cross-Ref]

3) Muir-Hunter SW, Wittwer JE: Dual-task testing to predict falls in community-dwelling older adults: a systematic review. Physiotherapy, 2016, 102: 29–40. [Medline] [CrossRef]

4) Gillespie LD, Robertson MC, Gillespie WJ, et al.: Interventions for preventing falls in older people living in the community. Cochrane Database Syst Rev, 2012, 12: CD007146. [Medline]

5) Gates S, Smith LA, Fisher JD, et al.: Systematic review of accuracy of screening instruments for predicting fall risk among independently living older adults. J Rehabil Res Dev, 2008, 45: 1105–1116. [Medline] [CrossRef]

6) MacRae PG, Lacourse M, Moldavon R: Physical performance measures that predict faller status in community-dwelling older adults. J Orthop Sports Phys Ther, 1992, 16: 123–128. [Medline] [CrossRef]

7) Vellas BJ, Wayne SJ, Romero L, et al.: One-leg balance is an important predictor of injurious falls in older persons. J Am Geriatr Soc, 1997, 45: 735–738. [Medline] [CrossRef]

8) Bonetti LV, Hassan SA, Kasawara KT, et al.: The effect of mental tracking task on spatiotemporal gait parameters in healthy younger and middle- and older aged participants during dual tasking. Exp Brain Res, 2019, 237: 3123–3132. [Medline] [CrossRef]

9) Chen LK, Woo J, Assantachai P, et al.: Asian Working Group for Sarcopenia: 2019 Consensus update on sarcopenia diagnosis and treatment. J Am Med Dir Assoc, 2020, 21: 300–307.e2. [Medline] [CrossRef]

10) Sadeghi H, Allard P, Prince F, et al.: Symmetry and limb dominance in able-bodied gait: a review. Gait Posture, 2000, 12: 34–45. [Medline] [CrossRef]

11) Harada T, Miyai I, Suzuki M, et al.: Gait capacity affects cortical activation patterns related to speed control in the elderly. Exp Brain Res, 2009, 193: 445–454. [Medline] [CrossRef]

12) Holtzer R, Mahoney JR, Izzetoglu M, et al.: fNIRS study of walking and walking while talking in young and old individuals. J Gerontol A Biol Sci Med Sci, 2011, 66: 879–887. [Medline] [CrossRef]

13) Mirelman A, Maidan I, Bernad-Elazari H, et al.: Increased frontal brain activation during walking while dual tasking: an fNIRS study in healthy young adults. J Neuroeng Rehabil, 2014, 11: 85. [Medline] [CrossRef]

14) Chib VS, Yun K, Takahashi H, et al.: Noninvasive remote activation of the ventral midbrain by transcranial direct current stimulation of prefrontal cortex. Transl Psychiatry, 2013, 3: e268. [Medline] [CrossRef]

15) Beurskens R, Bock O: Age-related deficits of dual-task walking: a review. Neural Plast, 2012, 2012: 131608. [Medline] [CrossRef]

16) Woollacott M, Shumway-Cook A: Attention and the control of posture and gait: a review of an emerging area of research. Gait Posture, 2002, 16: 1–14. [Medline] [CrossRef]

17) Ghai S, Ghai I, Effenberg AO: Effects of dual tasks and dual-task training on postural stability: a systematic review and meta-analysis. Clin Interv Aging, 2017, 12: 557–577. [Medline] [CrossRef]

18) Wollesen B, Wanstrath M, van Schooten KS, et al.: A taxonomy of cognitive tasks to evaluate cognitive-motor interference on spatiotemoporal gait parameters in older people: a systematic review and meta-analysis. Eur Rev Aging Phys Act, 2019, 16: 12. [Medline] [CrossRef]

19) Hortobágyi T, del Olmo MF, Rothwell JC: Age reduces cortical reciprocal inhibition in humans. Exp Brain Res, 2006, 171: 322–329. [Medline] [CrossRef]

J. Phys. Ther. Sci. Vol. 34, No. 3, 2022

182