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ORIGINAL RESEARCH

The Effect of Cognitive-Motor Dual Tasks on the Risk of Falls in Female Saudi Students: A Cross-Sectional Study

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Introduction: Dual tasking (DT) requires individuals to carry out two actions simultaneously, comparable to how the brain can perform a cognitive function while the body is in motion, which eventually enhances human balance. This paper aims to examine and compare the impact of DT on the risk of falling (ROF) among Saudi female students.

Methods: A cross-sectional design was used. 120 female students were recruited and divided into two groups: literary group (LG) (n = 34) and scientific group (SG) (n = 86). Participants, aged 18–25, had a normal body mass index (BMI) and cognitive and balancing skills. ROF was measured using the Biodex balancing device for balance alone (no DT) and with DT (motor and two cognitive tasks). After three trials, the mean and average were calculated. The ICC calculation showed a reliable result of <0.8. BMI was represented as the mean (M) and standard deviation (SD) for both groups. ROF was compared within and between groups using paired and unpaired T-tests. Mann–Whitney compared the two groups throughout DT. The level of significance was P = 0.05.

Results: There was no significant difference in ROF in SG (P = 0.06) between the performance with and without a DT; on the contrary, LG demonstrated a significant difference (P = 0.001) for the same tests. In addition, the only time there was a significant difference between the two groups was when they performed DT (P = 0.006).

Conclusion: Female students who used critical and analytical thinking and motor performance in their study and daily routine were more balanced and resistant to falling than their peers who did not. This study may improve efficient treatments for fall prevention and balance. Future research could investigate the complex nature of additional DT that may be complicated by gender and BMI outside of the normal range.

Keywords: dual tasks, risk of fall, cognition, balance

Introduction

Dual tasking (DT) requires individuals to perform two tasks concurrently, comparable to the brain's ability to undertake a cognitive activity while walking. The investigation revealed a relationship between the central nervous system and movement; this link discussed the brain's participation in cognitive activities when walking.[1,2] During DT, the prefrontal cortex and anterior cingulate cortex are two areas of the brain that are generally engaged. Training these parts of the brain may enhance a person's balance and reduce the likelihood of their falling.[3] The relationship between cognitive decline or deterioration and slowness of motion, including gait velocity, cadence, step, and stride duration, was identified by researchers.[4–6] People with neuromuscular disorders, such as Alzheimer's and stroke, walk slower than individuals with mild cognitive impairment, who walk slower than those with cognitive health.[4–6] There is a relationship between cognitive function and walking speed. Poor mental executive function has still been associated with falls.[6]

It has been demonstrated that a person's capacity to maintain balance decreases when performing two or more tasks simultaneously.[7–11] Findings showed that when individuals walked while conversing, they either stopped walking or required more time to complete their gait task.[12] Walking is a task that involves a high level of physical mobility as well

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as cognitive flexibility to plan and execute movement.[13] DT increases the stimulation of movement-controlling areas in the brain, activating the release of neurotransmitters that increase the speed and adequacy of brain cells, particularly in the frontal lobe, consequently improving cognitive and motor performance.[14] In addition, cognitive-motor DT training enhanced functional performance greater than single-task training.[15,16] In several studies comparing moderate cognitive impairment to severe cognitive impairment, researchers assessed the elderly's balance and risk of falling. There was a correlation between a higher risk of falling and severe cognitive impairment.[17,18] Engaging in cognitive tasks like conversation or problem-solving while walking can divide cognitive resources, potentially diminishing focus on the physical task and increasing the risk of falls. Furthermore, cognitive demands could impede motor control. Distraction may reduce an individual's capacity to maintain balance, leading to instability.[17,18] By applying findings from dual-task research, schools and health professionals can create more effective fall prevention strategies and educational practices. In schools, for example, incorporating movement-based learning can help students practice multitasking effectively. Furthermore, healthcare professionals can implement dual-task assessments as part of routine evaluations to identify individuals who may have higher fall risks.[17–19] A scoping analysis conducted in Saudi Arabia identified a total of 20,136 children who were at risk of falling. Among them, 69% were males. Falls accounted for 31.9% of the incidents, while MVCs accounted for 25.1% of them. The leading cause of fractures was responsible for 37.9% of cases, followed by MVC (21.5%). The results of this study can provide valuable guidance for implementing preventative measures to decrease the impact of injuries, enhance the overall health of the population, and prompt additional research on the factors that contribute to population injuries in Saudi Arabia.[19]

In Saudi Arabia, there are two categories of higher education institutions: literary colleges (Sharia and arts) and scientific colleges (medicine and science). More than half of the roughly one million university and college students in Saudi Arabia are female.

Because different educational institutions specialise in a variety of fields, the curriculum for the educational programmes that are made available by these institutions is organised differently. The theoretical portion of higher education places a distinct emphasis on learning in contrast to the more hands-on, practical scientific portion of higher education. It was obvious that courses at scientific and practical colleges required frequent movement and the execution of numerous tasks simultaneously, allowing students to participate in multiple cognitive processes while doing physical activities (dual tasks). However, research has examined how incorporating movement into the learning process activates kinesthetic perception and allows learning to take place.[20] In addition, no previous research in Saudi Arabia has examined the relationship between performing two tasks simultaneously, the type or nature of students' study, which demands both mental and physical abilities, and the risk of falling or the capacity to maintain balance while performing both tasks. This paper aims to investigate the impact of DT on balance and the risk of falls among Saudi female science and literature students. Furthermore, to determine if there is any relationship between a student's study approach and the risk of falling while carrying out a dual task in order to reduce the percentage of injuries related to falling. The study approach in some colleges emphasizes the importance of critical thinking, analysis, evaluation, and synthesizing information and knowledge.

Methods

Subjects

An announcement of research was given to 150 female students on a campus where only women teach at the University of Umm Al-Qura, Saudi Arabia. This notice was accompanied by an invitation letter and a proposal that described the research and its purpose, the necessity for participants to be present, the prerequisites for participation, as well as the significance of their attendance and involvement. 120 (80%) of the 150 participants who consented to participate in the study were emailed the consent form. Specialization led to the formation of the scientific (SG, 86) and literary (LG, 34) groups that also facilitate enrollment according to students specialties. All participants, aged 18 to 25, had a normal BMI and normal cognitive and balance skills. For research purposes, the first group was known as the scientific group (SG), whereas the second was known as the literary group (LG) (Figure 1). Any healthy female student currently enrolled in courses at the University of Umm Al-Qura was eligible to participate in the study. Students who exhibited any cognitive,

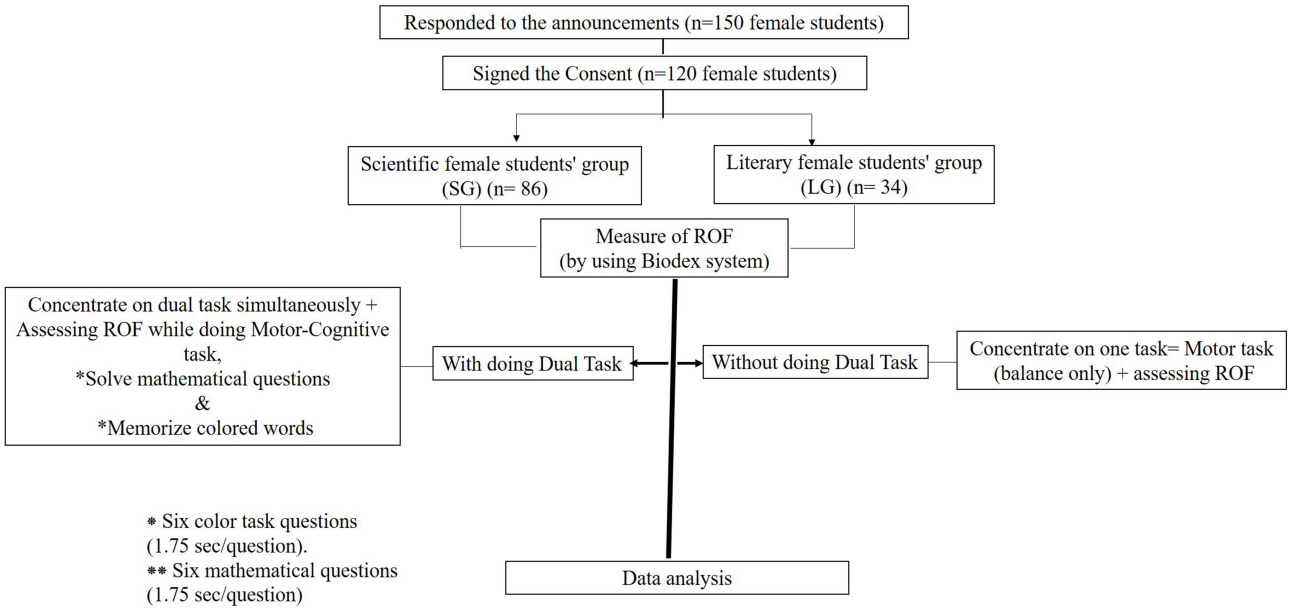

Figure 1 The flowchart shows the data collection method.
Abbreviations: ROF, Risk of Fall; n, Number; DT, Dual task.

visual, auditory, neurological, or balance impairments were excluded from participation. The study complies with the Declaration of Helsinki. The Biomedical Research Ethics Committee for Scientific Research at Umm Al-Qura University provided their approval for this study, HAPO-02-K-012-2022-11.

Instruments

The Biodex Medical Balancing Systems (230 VAC #950-302, NY, USA, at Umm Al-Qura University Labs) was used to figure out the risk of fall both when people were at dual-tasking and when they were not. Each test had three separate trials. The system consisted of a movable balance platform, support rails, a color touchscreen display, and a printer.[21] By comparing balance test results to age-dependent normative data, the Balance System SD might identify a possible issue in two minutes. The protocol for fall risk assessment conforms to American Geriatrics Guidelines.[21,22]

Procedure

The participants were instructed to remove their shoes, socks, and any other items of clothing that may influence the results of the risk of falling test. Everyone was given extremely detailed instructions on the procedure and a warm-up protocol before performing the trial. After instructing subjects to stand on the Biodex (Figure 2A) with their feet positioned at (LTD6, RTD16, angle 10 degrees), their potential for falling was assessed (without the use of DT). Additionally, participants attempted to maintain a vertical projection by gazing at a vertical screen 30 cm in front of their face, while maintaining their center of gravity in the middle of the platform. After 3 repetitions, the mean was calculated (Figure 2B).

The participant retook the examination while engaging in a dual task that included a cognitive task (mathematical operations and memory functions). A laptop was placed in front of each participant, and while their COG was being monitored by the Biodex system, a PowerPoint slideshow with cognitive and memory questions was shown. The slides were timed, and the reaction time for each question was set at 1.75 seconds. The cognitive examination (Figure 3A) consisted of six simple fundamental arithmetic operations(like the sum of 1 and 3), and each of the six additional questions on colours (Figure 3B) required the participant to identify the displayed words by their colour rather than by the word's name as it appeared in the text (a similar procedure was performed by another researcher on a mobile screen; however, in this study, minor modifications were performed on the test using a timed PowerPoint slide show on a computer screen) (Figure 3). After completing three separate trials, the mean and average were calculated. In

Figure 2 The Biodex System (**A**) was implemented throughout the data collecting phase of the postural stability testing (**B**) to provide consistent, reliable, and objective data for measuring ROF with and without DT.

Figure 3 A PowerPoint slideshow presented the cognitive (**A**) and memory (**B**) questions, and the participant was told to keep their center of gravity throughout the three trials. The reaction time for each question in this PowerPoint slideshow was set at 1.75 seconds. (**C**) The overall stability index which represents fall risk index (FRI) of a participant during test.

a discussion forum, one of the researchers verifies the accuracy of the questions' responses. A second researcher supervised the laptop with the cognitive and memory tests. Both researchers guaranteed that the participant did not move feet or hands during the examination.

The result appeared on the screen as an arrow, accompanied by a graded bar of various colors and numbers. Each color represents an age group, and the number corresponds to the risk fall coefficient for that age group (Figure 3C). The index of overall stability, which is the rearresting the fall risk index, is measured in degrees (where 0° is the best possible value), and higher scores indicate poor dynamic balance (0 to 2.25 for ages between 17 and 35 years old).[23]

Statistical Analysis

GraphPad Prism 9.5.0 (730) was used for data analysis. The results of the statistical analysis for the scientific group (SG) and the literary group (LG) with a normal BMI were represented as the mean (M) and standard deviation (SD). Levene's

test revealed that the ROF of both groups was identical when assessed with and without the DT. A paired *T*-test was utilised to compare the ROF within each group. An unpaired *T*-test was utilised to compare ROF between the two groups. During dual tasks, the Mann–Whitney test was also used to analyse the median differences in memory and mathematical operations between the two groups. The ICC was calculated with a good reliability value (<0.8).

Results

Participating in this study were a total of one hundred and twenty Saudi female students. In all, there were 86 students enrolled in the scientific group (SG), and another 34 students were enrolled in the literal group (LG). There was no significant difference between the two groups in terms of age, weight, height, or body mass index (BMI). In addition, there were no significant differences in the ROF between the two groups before they did DT (P > 0.05). Table 1 shows the collected demographic data.

The findings indicated no significant difference in ROF between using DT and not using it at SG (P = 0.06). At LG, on the other hand, a significant difference in ROF was recorded between having DT and not having it (P = 0.001) (Table 2).

In addition, the findings demonstrated that the risk of falling during DT was noticeably higher in LG when compared to SG. The mean differences between the two groups in terms of DT performance are shown in Figure 4 (P = 0.006).

The median SG differences for memory and math scores were five and four, respectively. In comparison, the LG had median scores of 3.50 and 2.33 for memory and math tasks, respectively. There were significant differences between the two groups (P = 0.001) (Table 3).

The median score differences (between both groups) of the mathematics task (1.670) were higher than the median score differences of the memory task (1.50) (Figure 5).

Table 1 Demographic Characteristics of All Subjects; Data Were Collected From 120 Females

Variables	SG Mean ± SD	LG Mean ± SD	T value	P value
Age (Yrs.)	19.9 ± 1.48	20.4 ± 1.69	1.235	0.09
Weight (Kg)	59.4 ± 11.12	60.7 ± 13.62	0.409	1.20
Height (Cm)	157.2 ± 6.38	156.6 ± 6.15	1.430	0.12
BMI	20.9 ± 2.04	21.9 ± 1.93	4.469	0.13

Abbreviations: BMI, Body mass index; SD, Standard deviation; SG, Scientific group; LG, literary group; Yrs, Years; Kg, Kilogram; Cm, Centimeter.

Table 2 A Comparison of ROF Between Groups of Normal BMI With and Without Doing DT

Variables	SG (M ± SD)	LG (M ± SD)	Mean of Differences	SEM	T	P-value
ROF (without DT)	1.45 ± 0.81	1.62 ± 0.86	0.26	0.02	10.61	0.06
ROF (with DT)	1.71 ± 0.74	2.68 ± 0.85	0.96	0.16	5.745	0.0061*

Note: *Significant.
Abbreviations: ROF, Risk of fall; DT, Dual task; SG, Scientific group; LG, literary group.

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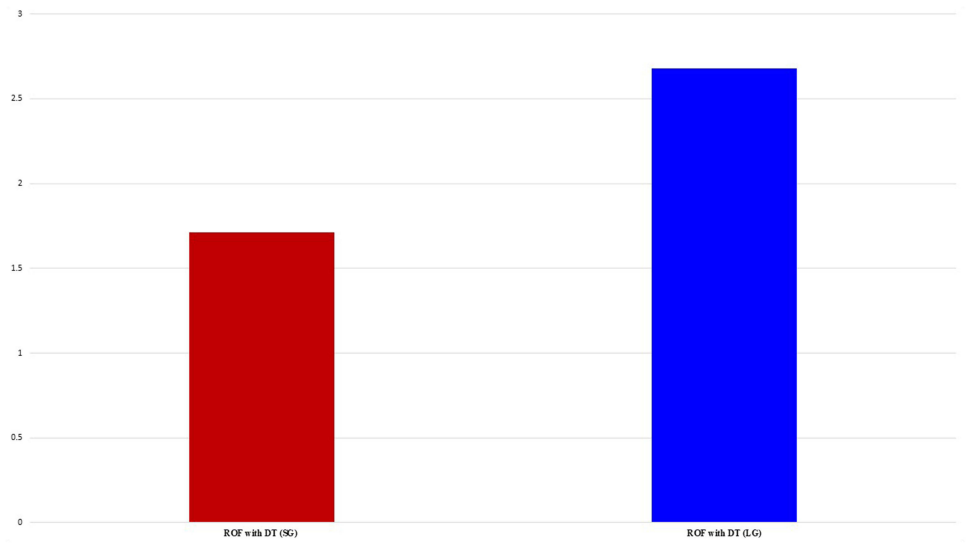

Figure 4 Comparison of the relative mean of the risk of fall (ROF) values of the two groups with doing dual task (DT). During DT, the ROF was higher in literary group (LG) than in scientific group (SG).

Discussion

The findings showed that ROF mean values differed depending on whether DT was performed or not at SG. However, the observed difference was not statistically significant, indicating that scientific college students may have superior balance and be able to avoid falling when juggling several duties (dual tasks).

Since students in scientific colleges have better environments for moving around and completing their work than students in other colleges, the response chosen depends not only on the characteristics of the external postural displacement but also on the individual's expectations, goals, and prior experiences. While cues were being employed, all motions were executed at the same speed, and the platform's stability gradually decreased. The work into brain mapping has mostly focused on identifying activity fluctuations.[24,25]

The current study provides a statistically significant difference between the incidence of LG student falls without and during the performance of DT. This may be understood to suggest that even if the LG has good balance because they do not multitask (not doing dual tasks), the chance of falling would increase if another activity or task was added (dual tasks). This finding may be a result of the fact that when only one task was done (rather than two), the emphasis was only on balance, and participants acquired expertise in this area. The current results showed no discernible difference between the two groups in the probability of ROF prior to the dual task, which supported that. Since balance was the sole task assigned, when a participant is focusing on only one task, brain activity increases. This enhances the probability that the person will not fall and assists them in maintaining proper posture.[26,27]

In contrast, when participants conducted dual tasks, the focus was on both balance and operations. Every conventional dual-task methodological model has employed either mathematical operation or memory while the participant performed a motor activity, resulting in a minor drop in one or both activities. According to the findings, the physical and/or cognitive

Table 3 A Comparison of Memory and Mathematics Tasks Between Groups of Normal BMI With and Without Doing Dual Tasks

Variables	SG	LG	Median Differences	Mann–Whitney U	P-value
	Median	Median			
Memory Score	5.00	3.50	1.50	323	0.0001*
Mathematics Score	4.00	2.33	1.67	434.5	0.0001*

Note :*Significant.
Abbreviations: SG, Scientific group; LG, literary group.

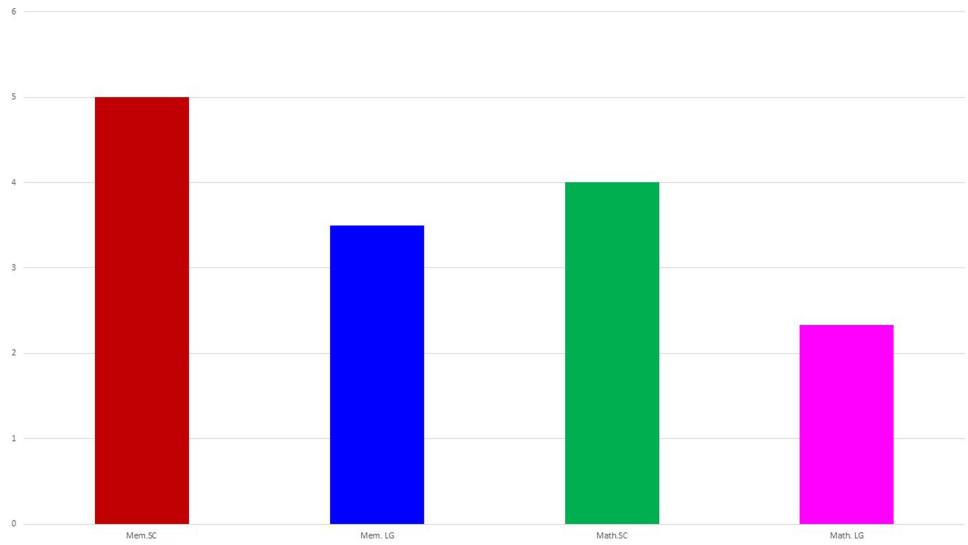

Figure 5 A comparison of the memory and mathematics performance between the two groups during DT. The median scores of the memory and mathematics performance were higher in the scientific group (SG) than the literary group (LG).

performance of the individuals was much poorer than anticipated. Researchers have determined that an increase in cognitive load while doing a physical activity leads to an increase in cortical inhibition and a concomitant increase in reaction time.[28]

This study showed a significant difference in ROF between SG and LG when executing DT tasks. This indicates that the SG performed well throughout dual tasks and was able to maintain their balance with better memory and mathematical results than the LG. Significant differences in both memory and math scores between the two groups (SG and LG) were also recorded. However, the difference in mathematics (1.67) results between the two groups was considerably greater than the difference in memory scores (1.50). This study revealed that LG did slightly better on memory questions than on mathematics issues. However, the ROF was much higher than expected in this group each time a math question was asked but not answered (a combination of balance and memory performed better than mathematics in LG). This could be attributed to the fact of sway velocity reduction during the dual-task condition. Researchers noticed a decline in balance when cognitive activities were conducted simultaneously and a slight decrease in one or both measures throughout the completion of two tasks.[29–32]

In addition, unlike modules taught at literacy colleges, modules taught in scientific colleges include mathematical operations. It was clear that those majoring in science and technology may be better able to focus on two tasks simultaneously than students majoring in arts and humanities, such as maintaining their balance, memorising mathematical procedures, or doing mathematical operations.

The management of the body's sway and the brain's activities are not two separate systems,[33] so the development of postural control may have been influenced by the environment. Less than one-third of the study participants were able to divide their attention between keeping their balance and doing the given task. This supports previous studies indicating that a subject's perception of balance may be enhanced by focusing on an external stimulus, such as a cognitive task, and that combining cognitive training with regular motor training is the best technique for ensuring patients' autonomy in their daily motor tasks and lowering the risk of falling and its consequences.[34,35]

Other investigations discovered the "posture-first" concept, which says that maintaining one's posture while simultaneously performing two activities involves a large amount of concentration; hence, balance control should take priority.[36,37] The brain is like a muscle; just as a muscle must be exercised and utilised to become strong, so too must the brain be exercised and utilised in order to achieve its greatest potential in terms of acting abilities. As a result, a brain that has been completely disregarded and not provided with opportunities for exercise may function poorly in a variety of circumstances.[38]

Limitations

One of the study's major limitations was that all of the subjects were female. This was linked to the Saudi Arabian educational system's requirement for gender separation in classes. Even with this limitation, applying the findings of this study to a larger

population should not be too difficult. In addition, the implications of this study's findings could potentially extend to a range of other fields. To evaluate the efficacy of perceptual-cognitive training interventions, for instance, a range of perceptual-cognitive training interventions may be conducted with professional athletes, surgery physicians, and drivers' licence holders.

Conclusion

It was concluded that students with a better ability to maintain balance and resist the risk of falling while engaging in motor-cognitive activities (dual tasks) had been exposed to a greater number of scientific modules, critical and in-depth thinking, and complicated issues throughout their education. The results were compared to those of students who were not forced to complete as many science courses. This is because solving these kinds of challenges may allow you to perform many tasks simultaneously. The findings of the study could have implications in cognitive rehabilitation, fall prevention programs, education training, workplace efficiency, and daily activity safety.

Data Sharing Statement

All data generated or analyzed during this study are included in this published article.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

1. Smith-Ray RL, Hughes SL, Prohaska TR, Little DM, Jurivich DA, Hedeker D. Impact of Cognitive Training on Balance and Gait in Older Adults. *J Gerontol B Psychol Sci Soc Sci*. 2015;70(3):357–366. doi:10.1093/geronb/gbt097
2. Zhang W, Low L, Schwenk F, et al. Review of Gait, Cognition, and Fall Risks with Implications for Fall Prevention in Older Adults with Dementia. *Dement Geriatr Cognit Disord*. 2019;48(1–2):17–29. doi:10.1159/000504340
3. Montero-Odasso M, Verghese J, Beauchet O, Hausdorff JM. Gait and cognition: a complementary approach to understanding brain function and the risk of falling. *J Am Geriatr Soc*. 2012;60(11):2127–2136. doi:10.1111/j.1532-5415.2012.04209.x
4. Abellan van Kan G, Rolland Y, Andrieu S, et al. Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) Task Force. *J Nutr Health Aging*. 2009;13(10):881–889. doi:10.1007/s12603-009-0246-z
5. Studenski S, Perera S, Patel K, et al. Gait speed and survival in older adults. *JAMA*. 2011;305(1):50–58. doi:10.1001/jama.2010.1923
6. Chen TY, Peronto CL, Edwards JD. Cognitive function as a prospective predictor of falls. *J Gerontol Ser B*. 2012;67(6):720–728. doi:10.1093/geronb/gbs052
7. Brown LA, Shumway-Cook A, Woollacott MH. Attentional demands and postural recovery the effects of aging. *J Gerontol a Biol Sci Med Sci*. 1999;54(4):165–171. doi:10.1093/gerona/54.4.M165
8. Kerr B, Condon SM, McDonald LA. Cognitive spatial processing and the regulation of posture. *J Exp Psychol Hum Percept Perform*. 1985;11(5):617–622. doi:10.1037/0096-1523.11.5.617
9. Teasdale N, Bard C, LaRue J, Fleury M. On the cognitive penetrability of posture control. *J Exp Aging Res*. 1993;19(1):1–13. doi:10.1080/03610739308253919
10. Brauer SG, Woollacott M, Shumway-Cook A. The interacting effects of cognitive demand and recovery of postural stability in balance-impaired elderly persons. *J Gerontol A*. 2001;56(8):M489–M496. doi:10.1093/gerona/56.8.M489
11. Shumway-Cook A, Woollacott M, Kerns KA, Baldwin M. The effects of two types of cognitive tasks on postural stability in older adults with and without a history of falls. *J Gerontol A*. 1997;52(4):M232–M240. doi:10.1093/gerona/52A.4.M232
12. Lundin-Olsson L, Nyberg L, Gustafson Y. Stops walking when talking as a predictor of falls in elderly people. *Lancet*. 1997;349(9052):617. doi:10.1016/S0140-6736(97)24009-2

13. Herold F, Hamacher D, Schega L, Müller NG. Thinking while moving or moving while thinking–concepts of motor-cognitive training for cognitive performance enhancement. *Front Aging Neurosci*. 2018;10:228. doi:10.3389/fnagi.2018.00228
14. Al-Yahya E, Mahmoud W, Meester D, Esser P, Dawes H. Neural Substrates of Cognitive Motor Interference During Walking; Peripheral and Central Mechanisms. *Front Hum Neurosci*. 2019;9(12):536. doi:10.3389/fnhum.2018.00536
15. Yokoyama H, Okazaki K, Imai D, et al. The effect of cognitive-motor dual-task training on cognitive function and plasma amyloid β peptide 42/40 ratio in healthy elderly persons: a randomized controlled trial. *BMC Geriatr*. 2015;15(1):1–10. doi:10.1186/s12877-015-0058-4
16. Holtzer R, Friedman R, Lipton RB, Katz M, Xue X, Verghese J. The relationship between specific cognitive functions and falls in aging. *Neuropsychology*. 2007;21(5):540–548. doi:10.1037/0894-4105.21.5.540
17. Bortoli CG, Piovezan MR, Piovesan EJ, Zonta MB. Balance, falls and functionality among elderly persons with cognitive function impairment. *Rev Bras Geriat Gerontol*. 2015;18(3):587–597. doi:10.1590/1809-9823.2015.14057
18. Tangen GG, Engedal K, Bergland A, Moger TA, Mengshoel AM. Relationships between balance and cognition in patients with subjective cognitive impairment, mild cognitive impairment, and Alzheimer disease. *Physl Ther*. 2014;94(8):1123–1134. doi:10.2522/ptj.20130298
19. Shoval E, Sharir T, Arnon M, Tenenbaum G. The effect of integrating movement into the learning environment of kindergarten children on their academic achievements. *Early Childhood Educ J*. 2018;46(3):355–364. doi:10.1007/s10643-017-0870-x
20. Albedewi H, Al-Saud N, Kashkary A, Al-Qunaibet A, AlBalawi SM, Alghnam S. Epidemiology of childhood injuries in Saudi Arabia: a scoping review. *BMC Pediatr*. 2021;21(1):424. doi:10.1186/s12887-021-02886-8
21. Scuffham P, Chaplin S, Legood R. Incidence and costs of unintentional falls in older people in the United Kingdom. *J Epidemiol Commun Health*. 2003;57(9):740–744. doi:10.1136/jech.57.9.740
22. Mundada PH, Dadgal RM. Comparison of Dual Task Training Versus Aerobics Training in Improving Cognition in Healthy Elderly Population. *Cureus*. 2022;14(9):1.
23. Prometti P, Olivares A, Gaia G, Bonometti G, Comini L, Scalvini S. Biodex fall risk assessment in the elderly with ataxia: a new age-dependent derived index in rehabilitation: an observational study. *Medicine*. 2016;95(10):e2977. doi:10.1097/MD.0000000000002977
24. Freeman C, Todd C, Camilleri-Ferrante C, et al. Quality improvement for patients with Hip fracture: experience from a multi-site audit. *BMJ Qual Saf*. 2022;11(3):239–245. doi:10.1136/qhc.11.3.239
25. Horak FB. Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls? *Age Ageing*. 2006;35 (suppl_2):ii7–ii11. doi:10.1093/ageing/afl077
26. Udina C, Avtzi S, Mota-Foix M, et al. Dual-task related frontal cerebral blood flow changes in older adults with mild cognitive impairment: a functional diffuse correlation spectroscopy study. *Front Aging Neurosci*. 2022;14. doi:10.3389/fnagi.2022.958656
27. Kriegeskorte N, Goebel R, Bandettini P. Information-based functional brain mapping. *Proc Natl Acad Sci*. 2006;103(10):3863–3868. doi:10.1073/pnas.0600244103
28. Broglio SP, Tomporowski PD, Ferrara MS. Balance performance with a cognitive task: a dual-task testing paradigm. *Med Sci Sports Exerc*. 2005;37 (4):689–695. doi:10.1249/01.MSS.0000159019.14919.09
29. McGeehan MA, Woollacott MH, Dalton BH. Vestibular control of standing balance is enhanced with increased cognitive load. *Exp Brain Res*. 2017;235(4):1031–1040. doi:10.1007/s00221-016-4858-3
30. Vuillerme N, Nafati G. How attentional focus on body sway affects postural control during quiet standing. *Psychol Res*. 2007;71(2):192–200. doi:10.1007/s00426-005-0018-2
31. Remaud A, Boyas S, Caron GAR, Bilodeau M. Martin Bilodeau Attentional Demands Associated with Postural Control Depend on Task Difficulty and Visual Condition. *J Motor Behavior*. 2012;44(5):329–340. doi:10.1080/00222895.2012.708680
32. Ghai S, Ghai I, Effenberg AO. Effects of dual tasks and dual-task training on postural stability: a systematic review and meta-analysis. *Clin Interventions Aging*. 2017;12:557–577. doi:10.2147/CIA.S125201
33. Teel EF, Register-Mihalik JK, Blackburn JT, Guskiewicz KM. Balance and cognitive performance during a dual-task: preliminary implications for use in concussion assessment. *J Sci Med Sport*. 2013;16(3):190–194. doi:10.1016/j.jsams.2012.09.007
34. Zhou Q, Yang H, Zhou Q, Pan H. Effects of cognitive motor dual-task training on stroke patients: a RCT-based meta-analysis. *J Clin Neurosci*. 2021;92:175–182. doi:10.1016/j.jocn.2021.08.009
35. Takakusaki K. Functional Neuroanatomy for Posture and Gait Control. *J Mov Disord*. 2017;10(1):1–17. doi:10.14802/jmd.16062
36. Peel NM, Alapatt LJ, Jones LV, Hubbard RE. The association between gait speed and cognitive status in community-dwelling older people: a systematic review and meta-analysis. *J Gerontol Ser*. 2019;74(6):943–948. doi:10.1093/gerona/gly140
37. Perez-Sousa MÁ, Del Pozo-Cruz J, Olivares PR, Cano-Gutiérrez CA, Izquierdo M, Ramirez-Vélez R. Role for Physical Fitness in the Association between Age and Cognitive Function in Older Adults: a Mediation Analysis of the SABE Colombia Study. *Int J Environ Res Public Health*. 2021;18(2):751. doi:10.3390/ijerph18020751
38. Kahya M, Gouskova NA, Lo OY, et al. Brain activity during dual-task standing in older adults. *J Neuro Eng Rehabil*. 2022;19(123):1–10.