Effects of cognitive and physical loads on dynamic and static balance of older adults under single, dual and multi-task conditions

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Abstract

Background: The aim of this study was to evaluate the effects of cognitive and physical loads on dynamic and static balance of older adults under single, dual and multi-task conditions. Methods: The effects of single versus combined (dual-task and multi-task) cognitive (to speak out the name of the weekdays in a reverse order) and physical (with three levels including handling weights of 1kg, 2kg and 3kg in each hand) loads on dynamic and static balance of 42 older adults (21 males and 21 females), aged ≥ 60 years were studied. Dynamic and static balance measures were evaluated using the Timed Up and Go (TUG) and stabilometer (sway index) tests, respectively. Results: The TUG speed of female participants was generally slower than that of male participants. Cognitive task influenced the participants' dynamic balance during the dual-task conditions, while the static balance was not affected in this phase. The dynamic and static balance measures were more influenced when performing the multi-tasks than when doing the dual-tasks. The effects of various levels of physical demand on the dynamic balance varied greatly under dual- and multi-task conditions. Conclusions: The findings add to the understanding of the factors influencing the elderly balance and control under cognitive and physical functioning.

Background

Falls are among the most common and serious problems among elderly people [1, 2, 3]. In the United States, there were 24,190 fatal and 3.2 million medically treated non-fatal fall related injuries among persons aged ≥ 65 years in 2012 [4]. Direct medical costs were $616.5 million for fatal and $30.3 billion for non-fatal injuries in that year, which increased to $637.5 million and $31.3 billion, respectively, in 2015 [4]. In addition to physical injury, falls can also have psychological and social consequences such as post-fall anxiety syndrome, fear of falling and loss of self-confidence and functional independence [1, 5]. The risk of falling and of being seriously injured in a fall increases with age due to physiologic and pathologic changes [5]. With the expected rapid increase in the aging population worldwide, there is a clear need to better understand the factors associated with falls in elderly people to develop interventions for fall prevention in this population.

A number of factors can contribute to falls in older adults. Gait and balance impairments have been regarded as the major risk factors for falling in this population [1, 2, 5, 6]. Older adults have stiffer and less coordinated gaits than young adults, and may be less capable of weight shifting or taking a rapid step to avoid falls when their balance is perturbed [5]. People often do several things simultaneously during standing or walking in daily life and many falls occur during the performance of such simultaneous tasks [2]. This phenomenon can be explained by the fact that performing a secondary task interferes with balance control, probably through divided attention (e.g., ability to carry out more than one task at the same time such as dual tasking) [5, 7]. For this, dual-task methodology has been used in a number of studies to understand the principles of postural control [2, 8, 9, 10].

Studies on the interaction between attention and postural control under a dual-task paradigm have yielded conflicting results depending on the task type and difficulty as well as individuals' age [8, 11, 12, 13]. Additionally, motor cognitive dual-task performance in previous studies generally involves simultaneous completion of a simple physical/motor task (e.g., walking) and a secondary cognitive task (e.g., counting backward, digit reversal or classification, presenting word lists for memorisation, etc.), which may not give a realistic insight into the effects in a work context. In other words, many daily and occupational activities require multi-task performance (e.g., multiple physical and cognitive demands). For example, people have to lift or carry loads as part of their daily routine or their occupation. Currently, there is limited knowledge about the effects of carrying loads of different weights on the elderly balance under multi-task conditions. It is important to consider how carrying loads of different weights along with cognitive activity as a measure of multi-task condition influences the elderly balance. Research to be conducted on this issue will have important implications in terms of the elderly balance and control under cognitive and physical functioning.

On the basis of the above-mentioned background, the objective of this study was to evaluate the effects of cognitive (to speak out the name of the weekdays in a reverse order) and physical (with three levels including handling weights of 1kg, 2kg and 3kg in each hand) loads on dynamic and static balance of a sample of older adults (aged 60 years and over) under single, dual and multi-task conditions.

Methods

Study design and participants

This study was semi-experimental in design. Study participants consisted of 42 older adults (21 males and 21 females) aged 60 years and over. The required sample size was calculated based on the main outcomes (e.g., dynamic and static balance measures) and factors (e.g., physical and cognitive demands) evaluated in the study, considering a 95% confidence level and a power of 80%. The study participants were selected through random sampling from the elderly who were under the coverage of an aging friendly centre located in Tabriz, Iran. The Mini-Mental Status Examination (MMSE) cognitive test was applied for screening of cognitively impaired cases and those volunteers scoring < 23 on this test were excluded [14]. Other inclusion criteria were: being 60 years or older and not using alcohol and drugs (particularly psychedelic, hypnotic, anticonvulsant, antidepressant, sedative consciousness, and impaired balance drugs) and an assistive device to walk. Participation in the study was on a voluntary basis and the participants were told that they were free to withdraw at any stage of the study. Each participant signed a written consent form before participation. The study protocol was reviewed and approved by the ethical review committee of the Tabriz University of Medical Sciences.

Study variables

Two dependent variables evaluated in the study were: 1) dynamic balance (by using the Timed Up and Go [TUG] test) and 2) static balance (by using a stabilometer). Independent variables included cognitive and physical loads. To perform the cognitive task (CT), each participant was instructed to speak out the

name of the weekdays in a reverse order as accurately as possible, starting from any random weekday specified by the investigator, similar to the protocol used in previous research [15]. The physical task (PT) had three levels and consisted of handling weights of 1kg (PT1), 2kg (PT2), and 3kg (PT3) in each hand (2kg, 4kg, and 6kg in total).

Data collection

Data were collected by using questionnaire, personal interview and experimental tests (for evaluation of dynamic and static balances). Participants were asked to complete a personal information questionnaire before undertaking the experimental test. The questionnaire included demographic details including the participants' age, gender (male, female), education level (primary/secondary, diploma, undergraduate, postgraduate), marital status (single, married), living condition (living with family or alone) and having chronic disease as well as other information such as illness history, sleep condition (good, not good) and history of falling during the past few months (no, yes). The participants were asked not to have any physical activity before undertaking the test.

The TUG test was used to measure the dynamic balance of participants. The TUG is a commonly used test in older adults as it is easy to administer and can be completed by the majority of participants [5]. It uses the time required that a participant takes to rise from a chair, walk 3 meters, turn around, walk back to the chair, and sit down. During the tests, the participants were instructed to wear their regular footwear and use any mobility aids that they would normally require, following the procedure described in the literature [5]. The time taken to complete this test was measured using a stopwatch.

A purpose-built stabilometer (Danesh Salar Iranian Co., Iran) was used to measure the static balance. This type of stabilometer has been shown to be valid and reliable in measuring static balance [16]. Measurements were taken while the participants were standing on both feet on the stabilometer platform (40 × 40 cm). Participants were instructed to stand in an upright standing posture on the stabilometer platform for 30 s with eyes open. They were asked to stand flat, without moving and look at a point that was in front of their eyes during each trial. The stabilometer sway index (SM.SI in % and cm), which is the numerical value of the standard deviation of the distance the participant moved away from the centre of balance [17], was used as a measure static balance in this study. Three repetitions of static balance measurements were made for each test condition (with a 20 s rest break between successive measurements), and their average value was used for subsequent analysis.

Procedure

On arrival, participants were given instructions about the aims and procedures of the experiment. The test equipment was then introduced and any questions were answered by the investigator. Each participant performed 16 different experimental conditions as follows: two single tasks (TUG and stabilometer tests without cognitive/physical task), eight dual-task conditions (TUG test with CT, TUG test with 3 levels of PT, stabilometer test with CT, and stabilometer test with 3 levels of PT), and 6 multi-task conditions (TUG test with simultaneous CT and 3 levels of PT, and stabilometer test with simultaneous CT and 3 levels of

PT). The order of presentation of the experimental conditions was randomised between the participants. Data were collected between 9:00 and 12:00 am in a lab environment. The experimental tests were carried out during a single session, and took approximately one hour to complete for each participant.

Statistical analysis

Data analysis was performed using the SPSS v.16. Independent sample t-test and one-way ANOVA analyses were used to evaluate gender and age differences. For parameter comparison in different experimental conditions, considering the single task test condition as the control group, mixed model analysis of variance (mixed model ANOVA) with repeated measures design was used. In this model, the parameters were estimated by the Restricted Maximal Likelihood (REML) method and the covariance structure was selected as first order autoregressive (AR1) based on Akaike Information Criteria (AIC). This was followed by Sidak's post hoc tests on adjusted means to explore the effects in more detail. $P < 0.05$ was considered as significant level for all tests.

Results

Demographic data

The demographic details of the study population are presented in Table 1. Their age ranged from 60 to 85 years (mean = 69.2 years; SD = 13.6 years). The majority of participants were married (83.3%). Among them, 47.6% had primary/secondary degree, 26.2% had diploma and 23.8% had undergraduate degree. Only 7.1% of them reported that they live on their own, while the rest lived with their spouse (35.7%), children (11.9%) or both (45.2%). Their major health problem was blood pressure (50%) and the majority of them (90.5%) indicated that they had no history of falling.

Gender and age differences

The results showed significant differences between males and females in terms of the TUG performance, but not the stabilometer indices (Table 2). As can be seen from Table 2, the TUG speed of female participants was generally slower than that of male participants. The results showed no significant difference in the TUG and sway index scores in terms of the age of participants.

Dynamic balance

The results of mixed model ANOVA (Table 3 and Fig. 1(a)) showed significant differences among task groups for dynamic balance (TUG) test ($p < 0.001$). According to the Sidak's post hoc tests, the TUG task was significantly different from the TUG and CT (TUG+CT) ($p < 0.001$) as well as from the TUG, CT and PT1 (TUG+CT+PT1) ($p < 0.01$), TUG, CT and PT2 (TUG+CT+PT2) ($p < 0.001$) and TUG, CT and PT3 (TUG+CT+PT3) ($p < 0.001$) conditions. The TUG+CT condition was significantly different from TUG+CT+PT2 ($p < 0.01$) and TUG+CT+PT3 ($p < 0.001$) conditions. The TUG and PT1 (TUG+PT1) condition was significantly different from TUG+CT+PT1 ($p < 0.001$), TUG+CT+PT2 ($p < 0.001$) and TUG+CT+PT3 ($p < 0.001$) test conditions. The TUG and PT2 (TUG+PT2) was significantly different from

TUG+CT+PT2 ($p < 0.001$) and TUG+CT+PT3 ($p < 0.001$) conditions. The TUG and PT3 (TUG+PT3) condition was also found to be significantly different from TUG+CT+PT2 ($p < 0.001$) and TUG+CT+PT3 ($p < 0.001$) conditions.

Static balance

The ANOVA results also showed significant differences among task groups for both static balance measures ($p < 0.001$) (Table 3, Fig. 1(a) and (b)). For both static balance measures, the post hoc tests indicated that the SM.SI and CT (SM.SI+CT) condition was significantly different from SM.SI, CT and PT1 (SM.SI+CT+PT1) ($p < 0.01$) and SM.SI, CT and PT2 (SM.SI+CT+PT2) ($p < 0.05$) test conditions. The results also showed that the SM.SI+CT+PT1 was significantly different from SM.SI and PT1 (SM.SI+PT1) ($p < 0.01$) and SM.SI and PT2 (SM.SI+PT2) ($p < 0.05$) conditions.

Discussion

The main objective of this study was to evaluate the effects of single versus combined (dual-task and multi-task) cognitive and physical loads on the dynamic and static balance in a sample of older adults. The main findings of the study were that the dynamic balance was generally more influenced by the experimental conditions than the static balance in the studied participants and the balance measures (both dynamic and static) were significantly varied under single, dual and multiple task conditions. The dynamic balance (assessed by the TUG test) of females was worse than that of males, while there was no significant difference in balance measures in terms of the age of participants. The findings can help to better understand the factors influencing the elderly balance and control under cognitive and physical functioning.

With regard to the effects of dual tasks on the elderly balance, it was found that the cognitive task had a significant effect on the dynamic balance, while the various levels of physical task had no effect in this regard. On the other hand, none of the dual tasks evaluated in the study influenced the static balance of the studied population. It, therefore, appears that the dynamic balance (evaluated using the TUG test) was generally more affected by the study variables than the static balance (evaluated by the sway index of the stabilometer test). More specifically, when it comes to the dynamic balance, it seems that cognitive functioning is more problematic than physical demands in this group of participants. This is of particular interest since cognitive functioning plays an important role in gait and balance [9, 10], and as noted earlier it is one of the contributing factors to falls in older adults. Considering the fact that fall injuries are one of the leading causes of health problems among the elderly worldwide, these finding can be used to develop appropriate injury surveillance and prevention programs. The findings clearly suggest that, as far as the dual tasks are concerned, careful attention should be paid to the cognitive status of the older adults in fall prevention programmes. In this regard, several investigators have proposed the benefits of cognitive training programmes as one of the possible interventions to improve balance and gait, thereby reducing falls in older adults [10, 18].

One of the major contributions of the present study is to report the effects of dual- and multi-task conditions on older adults' balance. As shown in this study, both dynamic and static balance measures were more influenced by performing multiple tasks than by dual task conditions. For both dynamic and static balance measures, the highest recorded values (in terms of task completion time and sway index measures) were recorded for the multi-task conditions (f, g and h conditions in Table 3). When performing the multiple tasks, a decrease in the dynamic balance was recorded as the level of physical load increased. This is despite the fact that the various levels of physical demands while performing the dual-task had no effect on the dynamic balance of the study participants. Taken together, these findings may suggests that the effects of various levels of physical demand on the older adults' dynamic balance may vary greatly under dual- and multi-task conditions. These findings clearly indicate that how increasing task difficulty (in terms of physical demands) can lead to impaired balance abilities in older adults. It therefore appears that the risk of falling in the elderly may be increased while performing a multi-task compared to when doing a dual-task. This is perhaps not surprising as the multi-task condition imposes combined cognitive and physical demands on the individuals as compared to performing single or even dual cognitive or physical tasks. Although there is no other similar study reported in the literature with which to compare the results, van Iersel et al. [2] who evaluated the effect of different cognitive dual-tasks on balance during walking in physically fit elderly people found an increase in body sway as a result of cognitive dual tasks compared to when walking without dual tasks. In another attempt, Pellecchia [8] conducted a study to determine whether postural sway varies with the difficulty of a concurrent unrelated cognitive task and found that attentional demands of the cognitive task impacted postural sway, with the most difficult cognitive task having the greatest influence. Nevertheless, the findings of this present study highlight the importance of physical aspects (e.g., varying levels of physical demand combined with cognitive task) in multi-task conditions as one of the factors influencing the elderly balance, and consequently the risk of falling in this population.

The results presented here regarding the effects of cognitive and physical functioning on the elderly balance are based on experimental conditions that were examined in this study and this should be taken into account when applying the findings. The use of TUG test as a measure of dynamic balance in the elderly in this study confirmed the diagnostic value of this test in assessing balance and risk of falling in elderly participants. Two other studies have also shown that doing a dual task affects people's balance and concluded that TUG with dual task can be considered as a good measure to evaluate balance and risk of falling in the elderly [19, 20]. Nevertheless, due to variability in measures, methodologies and individuals, uniform protocols or criteria may be required. Therefore, further research is required to generalise the findings of our work.

Conclusions

In conclusion, the findings of this study add to the understanding of the effects of performing single, dual and multiple physical and cognitive tasks on the dynamic and static balance of older adults. The results showed significant differences in the dynamic balance measure in terms of the gender of participants. When performing the dual tasks, only cognitive task influenced the dynamic balance of the study

participants, while the physical task levels had no effect. None of the cognitive and physical activities affected the static balance of the studied participants during the dual-task conditions. The dynamic and static balance measures were generally more affected while performing the multi-tasks than when doing the dual-tasks. The effects of various levels of physical demand on the participants' dynamic balance varied greatly under dual- and multi-task conditions.

Abbreviations

AIC: Akaike Information Criteria; ANOVA: AR: Autoregressive; Analysis of variance; CT: Cognitive task; MMSE: Mini-Mental Status Examination; PT: Physical task; REML: Restricted Maximal Likelihood; SM.SI: Stabilometer sway index; TUG: timed up and go

Declarations

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Availability of data and materials

The datasets used and analysed in this present study are available from the corresponding author (ID) upon reasonable request.

Authors' contributions

Study conception and design were performed by HA, GM and ID. Data collection was performed by HA and GM. Statistical analysis and interpretation of the results were carried out by ID and MAJ. The first draft of the manuscript was composed by ID. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

Ethics approval and consent to participate

This study was approved by the ethical review committee of the Tabriz University of Medical Sciences. All participants signed an informed consent form before participation.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1

Characteristics of study participants

Variables	N	%
Gender		
Male	21	50.0%
Female	21	50.0%
Age		
< 65	12	28.6%
65–75	21	50.0%
> 75	9	21.4%
Educational level		
Primary/secondary	20	47.6%
Diploma	11	26.2%
Undergraduate	10	23.8%
Postgraduate	1	2.4%
Falling history		
No	38	90.5%
Yes	4	9.5%
Marital status		
Single	7	16.7%
Married	35	83.3%
Health condition		
Blood pressure	21	50.0%
Blood sugar	7	16.7%
Heart disease	3	7.1%
No disease	11	26.2%
Living condition		
Alone	3	7.1%
With spouse	15	35.7%
With children	5	11.9%
With spouse and children	19	45.2%
Sleep condition		
Good	42	100%
Not good	0	0

Table 2

Gender and age differences in the dynamic and static balance measures

	Gender			Age (years)			
	Male	Female		< 65	65–75	> 75	
Variables	Mean (SD)	Mean (SD)	P-value[a]	Mean (SD)	Mean (SD)	Mean (SD)	P-value[b]
Dynamic balance							
TUG	**8.4 (9.0)**	**9.3 (1.9)**	0.003	8.9 (1.7)	8.4 (1.3)	9.7 (1.4)	0.082
TUG+CT	**9.2 (1.0)**	**10.0 (1.9)**	0.001	9.4 (1.8)	9.4 (1.4)	10.5 (1.4)	0.138
TUG+PT1	**8.5 (0.9)**	**9.5 (1.8)**	0.004	9.1 (1.6)	8.7 (1.3)	9.6 (1.7)	0.305
TUG+PT2	**8.9 (0.7)**	**9.8 (1.9)**	0.001	9.4 (1.6)	9.0 (1.4)	9.9 (1.5)	0.418
TUG+PT3	**9.0 (1.0)**	**10.1 (1.7)**	0.004	9.8 (1.6)	9.4 (1.3)	9.8 (1.7)	0.654
TUG+CT+PT1	**9.5 (1.1)**	**10.3 (2.0)**	0.001	9.8 (1.9)	9.5 (1.4)	10.8 (1.5)	0.157
TUG+CT+PT2	10.4 (1.6)	11.0 (2.0)	0.108	10.5 (2.0)	10.5 (1.7)	11.5 (1.8)	0.379
TUG+CT+PT3	**10.8 (1.5)**	**11.4 (2.2)**	0.032	11.0 (2.0)	11.0 (1.7)	11.0 (1.9)	0.851
Static balance							
(1) Sway index (%)							
SM.SI	5.1 (1.5)	5.3 (1.3)	0.572	5.6 (1.4)	4.7 (1.4)	5.7 (1.4)	0.121
SM.SI+CT	4.1 (1.3)	4.7 (1.4)	0.721	5.0 (1.3)	4.2 (1.2)	4.0 (1.8)	0.236
SM.SI+PT1	4.9 (1.6)	4.8 (1.9)	0.433	5.3 (1.5)	4.7 (1.9)	4.7 (1.8)	0.654
SM.SI+PT2	4.5 (1.5)	5.5 (1.6)	0.114	6.3 (1.6)	4.7 (1.9)	4.1 (1.8)	0.103
SM.SI+PT3	5.8 (1.4)	6.0 (1.5)	0.824	6.0 (1.9)	5.9 (1.8)	5.5 (1.7)	0.886
SI+CT+PT1	6.3 (1.8)	6.6 (1.7)	0.686	7.6 (2.0)	6.0 (1.9)	5.8 (1.8)	0.508
SI+CT+PT2	6.3 (1.7)	6.1 (1.6)	0.666	6.6 (1.9)	6.5 (1.9)	5.2 (1.8)	0.392
SI+CT+PT3	5.7 (1.8)	6.7 (1.7)	0.350	7.3 (1.8)	5.8 (1.8)	5.8 (1.7)	0.484
(2) Sway index (cm)							
SM.SI	1.0 (0.3)	1.0 (0.2)	0.561	1.1 (0.2)	0.9 (0.2)	1.1 (0.2)	0.118
SM.SI+CT	0.8 (0.2)	0.9 (0.2)	0.767	0.9 (0.2)	0.8 (0.2)	0.8 (0.3)	0.314
SM.SI+PT1	0.9 (0.4)	0.9 (0.3)	0.510	1.0 (0.4)	0.9 (0.3)	0.9 (0.3)	0.592
SM.SI+PT2	0.9 (0.3)	1.1 (0.5)	0.150	1.0 (0.4)	1.0 (0.4)	0.8 (0.3)	0.141
SM.SI+PT3	1.1 (0.4)	1.2 (0.5)	0.813	1.2 (0.3)	1.2 (0.4)	1.1 (0.5)	0.884
SM.SI+CT+PT1	1.2 (0.5)	1.3 (0.9)	0.860	1.5 (0.5)	1.2 (0.4)	1.1 (0.4)	0.554
SM.SI+CT+PT2	1.2 (0.5)	1.2 (0.4)	0.669	1.3 (0.4)	1.3 (0.4)	1.0 (0.3)	0.387
SM.SI+CT+PT3	1.2 (0.4)	1.4 (0.9)	0.446	1.5 (0.5)	1.2 (0.4)	1.2 (0.5)	0.427

Note: TUG: timed up and go test; CT: cognitive task; PT1: physical task 1 (handling of 1kg weight in each hand); PT2: physical task 2 (handling of 2kg weight in each hand); PT3: physical task 3 (handling of 3kg weight in each hand); SM.SI: stabilometer sway index.

[a] Significant difference (from t-test analysis) between genders.

[b] Significant difference (from ANOVA analysis) between three age groups.

Table 3

Descriptive statistics and AVOVA results for evaluation of the effects of cognitive and physical activities on the dynamic and static balance

Variables	Mean	SD	Min	Max	ANOVA
Dynamic balance					
a) TUG	8.8	1.5	5.7	12.3	
b) TUG+CT	9.6	1.5	6.1	12.5	
c) TUG+PT1	9.0	1.5	6.1	13.0	
d) TUG+PT2	9.3	1.5	6.2	13.1	
e) TUG+PT3	9.6	1.5	7.4	13.1	
f) TUG+CT+PT1	9.9	1.7	7.2	13.5	
g) TUG+CT+PT2	10.7	1.8	7.6	14.5	
h) TUG+CT+PT3	11.1	1.9	7.5	14.6	$p < 0.001$ [ab,af,ag,ah,bg,bh,cf,cg,ch,dg,dh,eg,eh]
Static balance					
(1) Sway index (%)					
a) SM.SI	5.2	1.4	2.6	8.3	
b) SM.SI+CT	4.4	1.4	1.8	7.5	
c) SM.SI+PT1	4.9	2.0	2.0	11.3	
d) SM.SI+PT2	5.0	2.4	2.1	14.5	
e) SM.SI+PT3	5.9	2.4	2.2	13.7	
f) SM.SI+CT+PT1	6.4	3.9	2.0	24.8	
g) SM.SI+CT+PT2	6.2	2.6	1.9	14.6	
h) SM.SI+CT+PT3	6.2	3.6	2.2	24.8	$p < 0.001$[bf,bg,cf,fd]
(2) Sway index (cm)					
a) SM.SI	1.0	0.2	0.5	1.6	
b) SM.SI+CT	0.8	0.2	0.3	1.5	
c) SM.SI+PT1	1.0	0.3	0.4	2.2	
d) SM.SI+PT2	1.0	0.5	0.4	2.9	
e) SM.SI+PT3	1.1	4.0	0.4	2.7	
f) SM.SI+CT+PT1	1.3	0.8	0.3	4.9	
g) SM.SI+CT+PT2	1.2	0.5	0.3	2.9	
h) SM.SI+CT+PT3	1.3	0.7	0.4	4.9	$p < 0.01$[bf,bg,bh,cf,fd]

Note: TUG: timed up and go test; CT: cognitive task; PT1: physical task 1 (handling of 1kg weight in each hand); PT2: physical task 2 (handling of 2kg weight in each hand); PT3: physical task 3 (handling of 3kg weight in each hand); SM.SI: stabilometer sway index. Superscript letters stand for statistical significance (from Sidak post-hoc comparisons) between the respective test conditions.

Figures

Fig. 1(a)

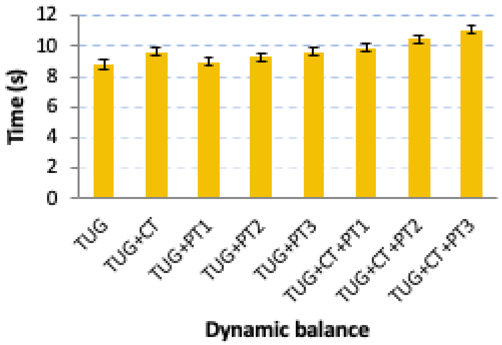

Fig. 1(b)

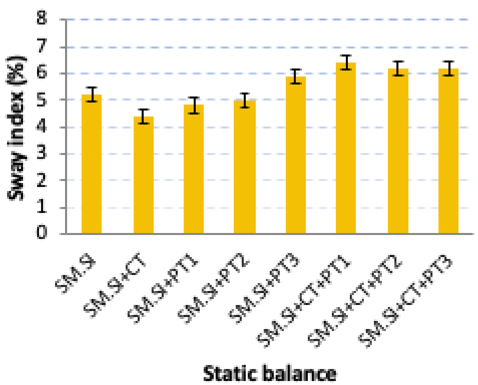

Fig. 1(c)

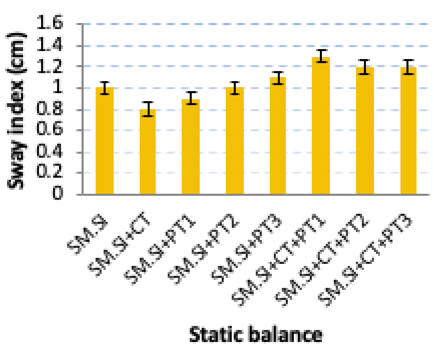

Figure 1

Dynamic balance (TUG test) (a), static balance (SM.SI in %) (b), and static balance (SI in cm) (c) of participants in different experimental conditions. Note: TUG: timed up and go test; CT: cognitive task; PT1: physical task 1 (handling of 1kg weight in each hand); PT2: physical task 2 (handling of 2kg weight in each hand); PT3: physical task 3 (handling of 3kg weight in each hand); SM.SI: stabilometer sway index. Error bars indicate standard errors.