Feasibility of Integrating Cognitive and Motor Functions into a New Balance Tracking System (BTrackS) Training Protocol

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Abstract

Many studies have shown that combining cognitive and motor tasks into one dual-task activity can prove to be beneficial in improving many gait parameters and balance. However, gaps in knowledge within this area of study still exist. Dr. Daniel Goble, professor at Oakland University, added a new cognitive-motor application to his Balance Tracking System (BTrackS). The present study had 17 adult participants complete this task three times each one week apart. The task involves standing on a force plate while looking at a screen displaying the plate, a yellow dot to represent the participant's center of pressure (COP) location, and letters for memorization to trigger the motor response. The system collects average response time, fastest response time, and accuracy. The statistical analyses included a one-way analysis of variance, Tukey's honestly significant difference, t-test, and intraclass correlation. Results showed that participants' average response time improved over three trials with an overall difference between the trial average response time means. Good reliability can be seen when looking at average response times between sessions one and two while excellent reliability can be seen when looking at the average response times between sessions two and three. There is poor reliability in the results on accuracy. It can be interpreted that improvements can be made over three trials on this new BTrackS cognitive-motor application when testing young, healthy adults with no balance impairments. The results also suggest that a practice trial would be beneficial.

Introduction

Cognitive tasks are defined as acquiring knowledge through mental processes using thought, experience, and the senses (Van der Fels et al., 2015). Motor tasks are defined as learned movement sequences designed to carry out a specific task (Van der Fels et al., 2015). There has been an increasing use of cognitive motor interference in rehabilitation settings when looking to improve balance function and gait, especially with older populations. When compared with single task activities, cognitive motor training provides additional benefits to balance function (Wang et al., 2015).

Single-task activities involve focusing on one activity repetitively, while dual-task exercises occur when simultaneously performing one primary activity and a secondary activity, such as a cognitive activity and a motor activity (Hofheinz et al., 2016). In a meta analysis by Wang et al. (2015), four studies assessed the effect of cognitive motor interference on balance using the Berg balance scale. These four studies found that the groups that received cognitive-motor interference training showed better performance on the Berg balance scale than the control group. A systematic review by Hofheinz, Mibs, & Elsner (2016) found that training protocols using dual-task (cognitive and motor tasks simultaneously) programs can significantly improve most gait parameters and balance function in stroke patients. Both Wang et al. (2015) and Hofheinz et al. (2016) agree that dual-task exercise training shows more improvement in gait parameters such as speed and stride length, center of pressure sway area, and Berg balance score when compared to single-task training.

There is much evidence to support the superiority of dual-task training over single-task training to improve gait and balance performance. Therefore, implementing dual-task cognitive-motor exercises in rehabilitation programs has the potential to benefit those who have suffered injuries or illnesses affecting these variables. Despite the benefits, a recent systematic review pointed out that there is a need to examine, "the relationship between improvements in cognitive skills and better performance in physical tasks, balance performance, and activities of daily living, after completing various kinds of cognitive and physical training" (Hagovská & Olekszyová, 2015). Another systematic review by He et al. (2018) assessing a total of 457 participants found that training cognitive-motor balance was effective in enhancing single-task balance function (standardized effect size = 0.27–1.82), but the effect of training cognitive-motor balance on dual-task balance ability was not studied. These reviews show that more research can be done to strengthen the arguments made by Wang et al. (2015) and Hofheinz et al. (2016) that dual-task exercise training leads to more improvement in multiple gait parameters when compared to single-task activities.

Dr. Daniel Goble, an Exercise Science professor at Oakland University and founder of Balance Tracking Systems Inc., has invented his own balance tracking force plate known as the Balance Tracking System (BTrackS). This device provides healthcare professionals and researchers with a balance assessment and training device to utilize in analyzing and helping improve peoples' postural stability over time (*Assess balance,* 2022). BTrackS can assess fall risk, functional neurology, balance, vestibular disorder risk, rehabilitation of neuro-optimization, and much more (*Assess balance,* 2022). A new application recently developed for BTrackS has the potential to aid further investigation in the effectiveness of dual-task cognitive-motor training. However, there is no existing feasibility or reliability data for this cognitive-motor task on BTrackS, as it is fairly new.

The present study aims to gather initial reliability and feasibility data for the cognitive-motor task on a sample of young, healthy adults as a basis for supporting further research. Specifically, the average response time during each trial over a three-week dual-task cognitive-motor training protocol was assessed in order to evaluate the feasibility of using BTrackS as a tool to strengthen cognitive-motor function. Measuring the average adult's overall cognitive-motor response time will help researchers begin to establish baseline data for this new BTrackS application when used in clinical settings. In addition, measuring average response time over three training sessions will also allow researchers to establish whether response time improvements can be made. Therapeutic clinicians can benefit from this research by potentially implementing this system into patients' rehabilitation plans.

Methods

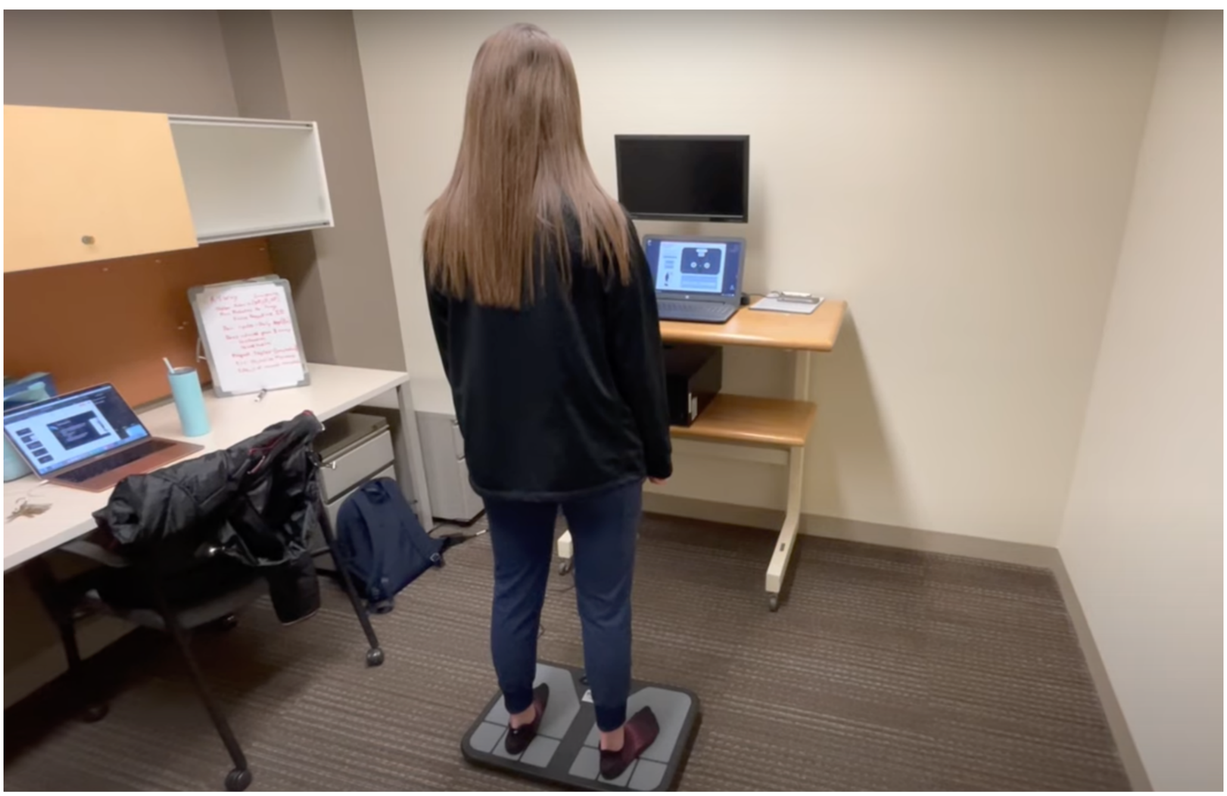
Participants

Recruitment for participants took place at Oakland University with the use of flyers asking for volunteers. 17 healthy, young adults aged 18 to 25 years old were recruited for participation. Informed consent was obtained from each participant prior to beginning assessment and training sessions. Prior to the first training session, health status regarding balance and dizziness problems was assessed for each participant. The questions regarding these concerns were consistent with the TriHealth Physicians Partners Health History Questionnaire (*Health history questionnaire*, 2012). The participants were asked if they had any history of falls and if they were experiencing or have a history of dizziness. None of the participants answered with concerns in any of these areas making all 17 adults qualified to participate. All experimental procedures were approved by the Oakland University Institutional Review Board (IRB). This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (Navalta, Stone, & Lyons, 2019).

Protocol

Participants attended a training session once a week for three weeks. Each session time slot was individually set by the participant and researchers. There was exactly one week between each training session. During each of the three sessions, the participant was given the exact same instructions to reduce any confusion on the task. During every session, each participant was asked to complete the three minute cognitive-motor task on the BTrackS force plate. The task requires the participant to stand on the BTrackS force plate while looking at a screen straight ahead (see Image 1 below). The screen displays a picture of the plate and a yellow dot representing the participant's center of pressure (COP) location. This yellow dot moves with the participant's sway.

Image 1: Stance and Set-Up for Task



Once the participant is standing on the plate and the three-minute task begins, he/she must hold the yellow dot in a centered circle shown on the screen for two seconds. Next, a letter appears on the screen for one and a half seconds (see Images 2 and 5 below). The participant must memorize this letter. After this letter disappears, two letters are displayed on the right and left sides of the plate (see Images 3 and 6 below). The participant must then shift his/her weight to move the yellow dot to the letter that was memorized if/when it appears (see Image 4 below). If the letter does appear on the right or left, it is considered a Go-task (see Images 2, 3, and 4 below). The Go-tasks occur randomly two-thirds of the time. Sometimes the letter that was flashed and memorized will not show up on the left or right side in which the participant must cancel (inhibit) his/her movement. This is known as a No-Go task (see Images 5, 6, and 7). The No-Go tasks occur randomly one-third of the time. This continues for three minutes. Response time and accuracy during both the Go- and No-Go tasks can be seen on the bottom of the screen. Results for response times and accuracy were recorded by the researchers during each of the participants' three sessions. After the conclusion of the third session, each participant was asked to answer two interview questions on his/her strategies for completing the task and any improvements that he/she suggested be made to the program.

Image 2: Flashing of Letter for Memorization for Example Go-Task

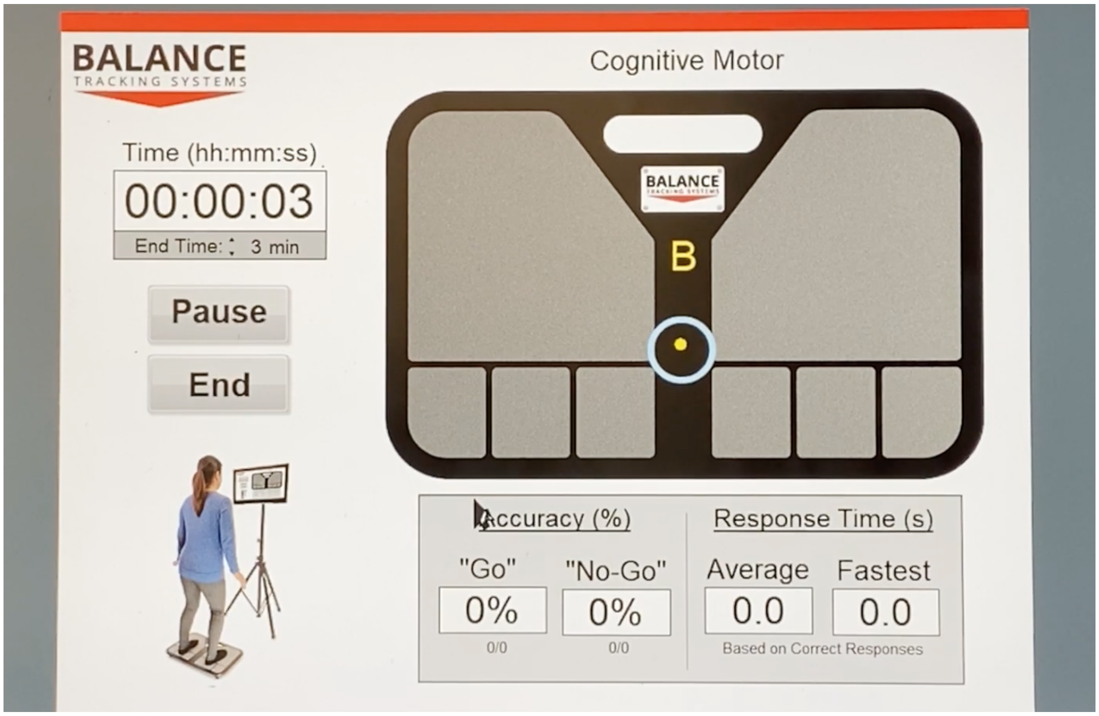


Image 3: Appearance of Letters for Response for Example Go-Task

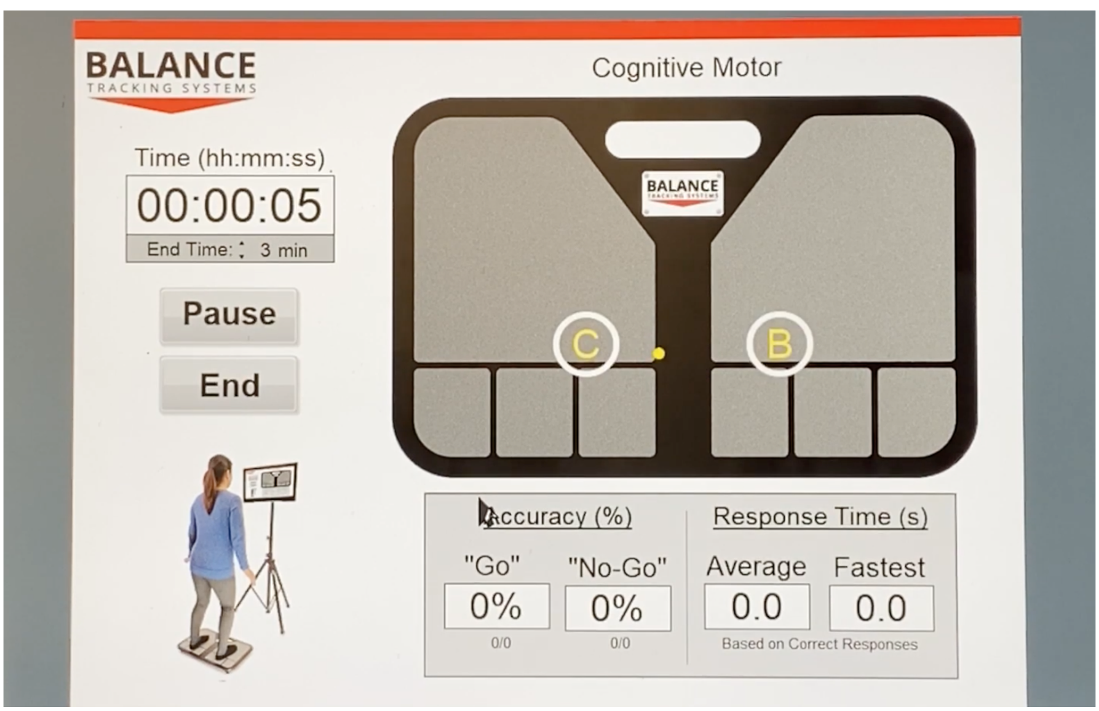


Image 4: Proper Response for Example Go-Task

Image 5: Flashing of Letter for Memorization for Example No-Go Task

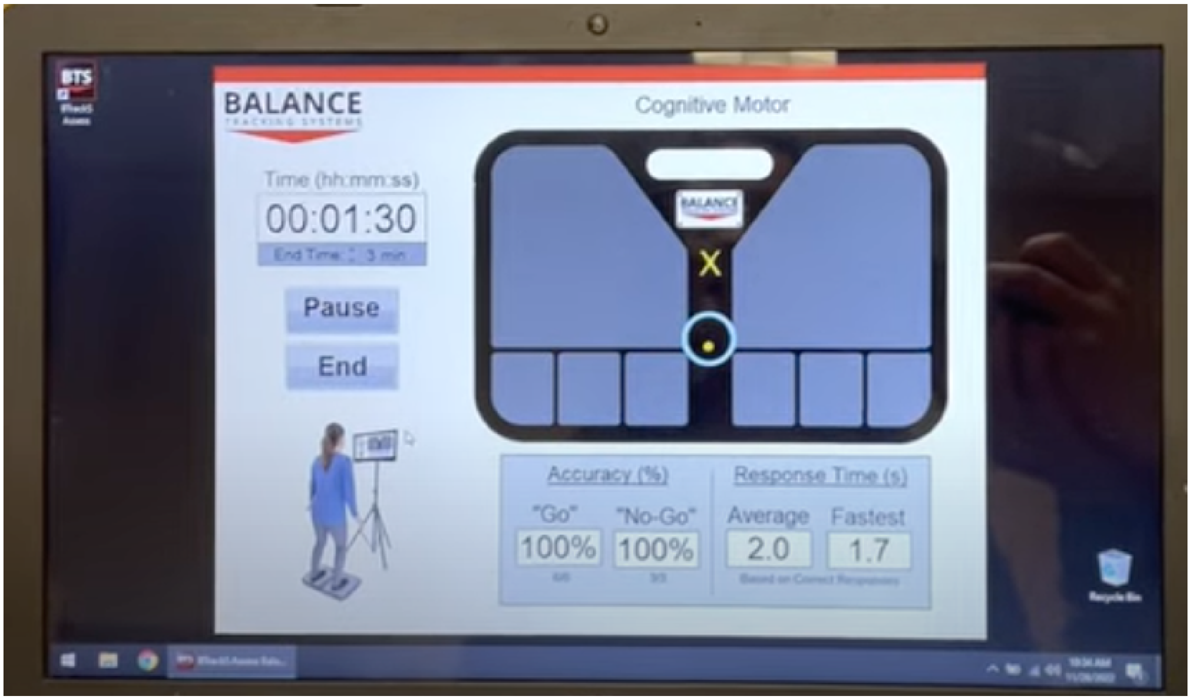


Image 6: Appearance of Letters for Response for Example No-Go Task

Image 7: Proper Response for Example No-Go Task

Statistical Analysis

A bar graph was created to represent the average response time of each trial for comparison. A one-way analysis of variance (ANOVA) was used to analyze the difference between the mean response times of the three trials. Then a Tukey's honestly significant difference (HSD) test was used to analyze pairwise comparisons in the ANOVA data. A t-test was used to measure the difference between the trials and compare it to the difference within the trials. Lastly an intraclass correlation (ICC) was run to help the researchers determine reliability of the measurements. An ICC value falls between 0 and 1 in which values below 0.40 indicate poor reliability, values between 0.40 and 0.59 indicate fair reliability, values between 0.60 and 0.74 indicate good reliability, and values 0.75 and above indicate excellent reliability.

Results

Figure 1: Average Response Time Per Trial

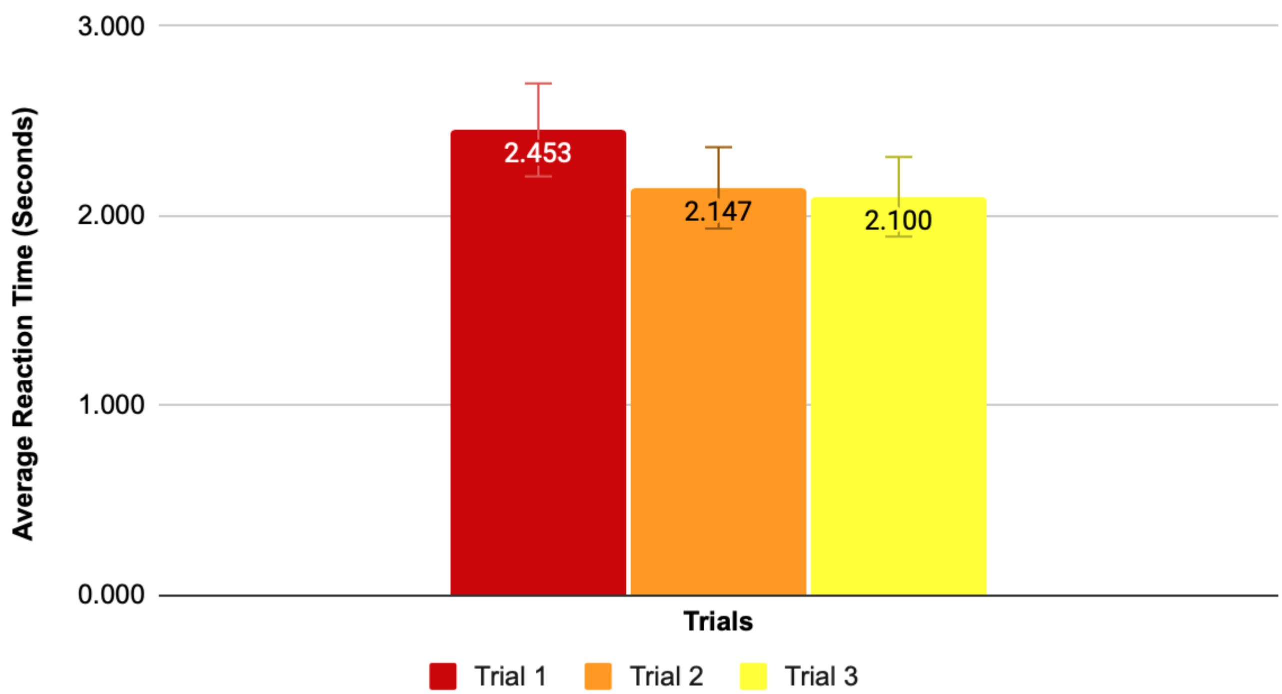


Figure 1 displays the mean of the average response times of the 17 participants for their first, second, and third training sessions in a bar graph for a visual comparison between sessions one, two, and three.

Table 1: Summary of Data

	Training 1	Training 2	Training 3
N	17	17	17
$\sum X$	41.7	36.5	35.7
Mean	2.4529	2.1471	2.1
$\sum X^2$	104.21	79.57	76.13
σ	0.3466	0.2741	0.2693

As shown in Figure 1, the mean response times decreased from one weekly session to the next. The *f*-ratio value is 7.0 (*p*=002).

Table 2: Post Hoc Tukey HSD

	Pairwise Comparisons	$HSD_{.05} = 0.2478$ $HSD_{.01} = 0.3134$	$Q_{.05} = 3.4203$ $Q_{.01} = 4.3243$
T_1:T_2	$M_1 = 2.45$ $M_2 = 2.15$	0.31	Q = 4.22 (p = .01219)
T_1:T_3	$M_1 = 2.45$ $M_3 = 2.10$	0.35	Q = 4.87 (p = .00338)
T_2:T_3	$M_2 = 2.15$ $M_3 = 2.10$	0.05	Q = 0.65 (p = .89036)

The improvement was specifically seen between trial one and trial two with no significant difference between trial two and trial three (Tukey HSD, Table 2).

Table 3: T-test

	T-Value
T_1:T_2	0.0001254014408
T_1:T_3	0.0002631092154
T_2:T_3	0.3321949847

Table 4: Intraclass Correlation Between Tests

	T_1-T_2	**T_2-T_3**	**All**

Average Response Time	0.68	0.75	0.63
Fastest Response Time	0.49	0.38	0.49
Accuracy of Go-tasks	0.05	0.08	0.19
Accuracy of No-Go tasks	0.05	0.07	0.08

As seen in Table 3, the average response time between the first and second trials (ICC=0.68) and between all trials (ICC=0.63) has good reliability while trials two and three (ICC=0.75) have excellent reliability. Fastest response time between the first and second trials (ICC=0.49) and between all trials (ICC=0.49) has fair reliability while trials two and three (ICC=0.38) have poor reliability. Accuracy of Go-tasks between tests one and two (ICC=0.05), tests two and three (ICC=0.08), and all three (ICC=0.19) have poor reliability. The accuracy of the No-Go tasks between trials one and two, trials two and three, and all three trials also have poor reliability (ICC=0.05, ICC=0.07, and ICC=0.08 respectively).

Discussion

The current investigation sought to provide baseline data for the new BTrackS cognitive-motor application by assessing young healthy adults. The participants' average response time improved over the three trials. Also, the significant f-value suggests that there is an overall difference between the trial average response time means. This suggests that improvements can be made over time on this application when testing young, healthy adults with no balance impairments.

The secondary purpose of this research was to assess the reliability of the new cognitive-motor application of BTrackS. Results from sessions one and two and also sessions one and three are statistically significantly different from each other. Due to the t-test outcomes, it is suggested that the difference between trials one and two and also trials one and three is reliable. The difference is not reliable when looking at sessions two and three. According to the ICC, good reliability can be seen when looking at average response time between sessions one and two, but excellent reliability can be seen when looking at the average response time between sessions two and three. These results suggest that a practice trial would be beneficial when using the cognitive-motor application for training since there is good test-retest reliability between second and third sessions after an introductory test. This supports work done in a previous study by Haworth et al. (2020) on the limits of stability (LOS) application of the BTrackS. In this study, the researchers found fair reliability from the first and second trial (ICC=0.583) and excellent reliability between the second and third trial (ICC=0.921). Even though the study by Haworth et al. (2020) used the LOS application, the same idea about the benefit of incorporating a practice trial still applies to the cognitive-motor application.

It is evident that response times are reliable but accuracy is not. Due to the nature of this task, there is not enough spread in the Go- and No-Go tasks to show reliability. Participants completing this task will most likely focus on accuracy which could be seen in the present study as there was little spread in the accuracy data. Therefore, in a rehabilitation setting, it would benefit clinicians to encourage patients to improve their average response times instead of only directing their focus to accuracy. This is suggested because the average response time results show reliability. Therefore, improving average response time is the suggested goal in a rehabilitation setting when utilizing the BTrackS cognitive-motor dual-task.

This study had multiple notable strengths. During each training session, the exact same instructions were given even if the participant claimed he/she remembered the task. This was incorporated to help eliminate any long-term memory issues. Another strength of the present investigation is that it is easy to replicate. Simple, straightforward equipment was used. BTrackS was developed to be user friendly. This was beneficial to the present study and will be beneficial to future investigations. Another notable strength that will benefit clinicians when incorporating the cognitive-motor task into rehabilitation programs is that the task is only three minutes long. This allows the task to be easily billable for insurance plans when it comes to rehabilitation therapy.

Despite this study's strengths, there are a few weaknesses. One weakness is that distractions were not eliminated within the room where the study was conducted. Noise, such as background talking, and distracting items around the room were not removed. In the future it would be beneficial to eliminate distractions. Conducting the study in a quiet environment to help participants focus on the task could lead to more accurate results. Another limitation of this study is that only 17 participants were recruited. Larger samples make it easier to find statistical differences. In the future, it would be beneficial to recruit a greater number of participants in order to receive more accurate results. Further investigation is warranted to also assess different populations on the cognitive-motor task.

Conclusion

Due to the results of the present investigation, it is suggested that average response time can significantly change between trials when testing young, healthy adults once a week for three weeks on the BTrackS cognitive-motor task. There is also excellent reliability when comparing sessions two and three but good reliability when comparing sessions one and two suggesting that a practice session would increase test-retest reliability. These results suggest that using the BTrackS cognitive-motor dual-task is feasible within a clinical setting. Rehabilitation specialists working with people with dizziness and/or balance impairments can incorporate this task into their patients' treatment plans to help strengthen cognitive-motor response times. Further investigations warrant testing on diseased populations to continue to grow the normative data for this new application.

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