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ARTICLE

The Effects of Texting, Sitting Surface Stability, and Balance Training on Simulated Driving Performance and Perceived Workload in Young and Older Drivers

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It has been shown that texting degrades driving performance, but the extent to which this is mediated by the driver's age and postural stability has not been addressed. Hence, the present study examined the effects of texting, sitting surface stability, and balance training in young and older adults' driving performance. Fifteen young (mean age = 24.3 years) and 13 older (mean age = 62.8 years) participants were tested in a driving simulator with and without texting on a smartphone and while sitting on a stable or unstable surface (i.e., a plastic wobble board), before and after a 30-min sitting balance training. Analyses of variance showed that texting deteriorated driving performance but irrespective of sitting surface stability. Balance training decreased the negative effects of texting on driving, especially in older adults. Perceived workload increased when drivers were texting, and balance training reduced perceived workload. Perceived workload was higher while sitting on the unstable surface, but less so after balance training. Path analyses showed that the effects on driving performance and perceived workload were (indirectly) associated with changes in postural stability (i.e., postural sway). The study confirms that texting threatens safe driving performance by challenging postural stability, especially in older adults.

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The study also suggests that it is important to further investigate the role balance training can play in reducing these negative effects of texting.

Keywords: aging, attention, distraction, postural stability

Safe or risky car driving is a highly complex activity, which is underpinned by a multitude of interacting cognitive, perceptual, motor, but also environmental constraints (Anstey, Wood, Lord, & Walker, 2005). One of the most influential factors leading to risky driving is distraction, which nowadays is increasingly caused by using mobile phones (e.g., reading and sending text messages). In fact, the use of mobile phones is considered one of the most significant contributors to car accidents (He, Chaparro, et al., 2014; Lee, Champagne, & Francescutti, 2013; Olson, Hanowski, Hickman, & Bocanegra, 2009). Accordingly, text messaging while driving has been associated with a significant increase in the risk of (near-) collision events (Caird, Johnston, Willness, Asbridge, & Steel, 2014; Gliklich, Guo, & Bergmark, 2016; Owens, McLaughlin, & Sudweeks, 2011; Yannis, Laiou, Papantoniou, & Christoforou, 2014). Also, experimental studies using simulated driving have indicated that compared with mobile phone conversations, text messaging has much more detrimental effects on driving performance (He, Chaparro, et al., 2014; Rumschlag et al., 2015). Presumably, text messaging not only forces the driver to have their eyes off the road and hands off the steering wheel but in trying to accomplish two tasks at once, also divides the driver's attention. Finally, a few studies suggest that dual tasks, including texting, can also negatively affect postural control by increasing postural sway, especially in more challenging environments (Hsiao, Belur, Myers, Earhart, & Rawson, 2020; see also Nurwulan, Jiang, & Iridiastadi, 2015; Rebold, Croall, Cumberledge, Sheehan, & Dirlam, 2017).

This brings us to a second important prerequisite for safe driving, namely postural stability. Unstable posture reduces perceptual sensitivity of visual and vestibular information (Treffner, Barrett, & Petersen, 2002), and thus may compromise a driver's capacity to appropriately control actions, such as steering (Riccio, 1995). In other words, a stable posture provides a stable frame of reference for perception and action (e.g., navigating, steering, velocity control, breaking) (Warren, 2006). It allows the pickup of information to control the dynamic relationship between the car and the environment (Gibson & Crooks, 1938). Although it is less common with more robust cars and improved roads, a badly paved road can challenge postural or sitting stability of car drivers. A few studies have suggested that a driver's level of postural control underpins safe driving (Anstey et al., 2005; Lacherez, Wood, Anstey, & Lord, 2013; Wood, Anstey, Kerr, Lacherez, & Lord, 2008). In these studies, researchers evaluated participants' on-road driving performance and correlated this to postural sway in off-road, laboratory tests (i.e., Lord's sway meter; Lord, Menz, & Tiedemann, 2003). It is not clear, however, to what degree standing sway is representative or indicative for an individual's postural control during seated driving. In this respect, only a few studies have captured postural stability during actual driving. Petersen, Barett, and Morrison (2008), for example, reported that drivers with less postural sway during driving (i.e., measured using an accelerometer placed at the seventh cervical vertebra) showed less lateral vehicle acceleration. In addition, Petersen and Barrett

(2009) did provide preliminary evidence suggesting that explicit instructions for maintaining a stable posture may contribute to driving safety.

The effects of more traditional balance training on driving performance is still unknown. A brief training using, for instance, balance boards can reduce postural sway (De Bruin, Swanenburg, Betschon, & Murer, 2009; Godard, Whitman, & Richmond, 2004; Hinman, 2002; Sachatello, Plotkin, & Dintino, 1999; Zech et al., 2010). Although not fully understood, balance board training is thought to enhance the use of optic flow information to control sway and/or to increase muscle strength and stiffness (Chagdes, Rietdyk, Jeffrey, Howard, & Raman, 2013). The effectiveness of balance training programs for postural control has also been documented among older adults. For example, it has been shown that a training program, using Swiss and BOSU balls reduced older adults' postural sway (i.e., lower levels of medial–lateral, and anterior–posterior center of pressure [COP] displacements; Martínez-Amat et al., 2013). However, whether such balance training can also facilitate driving performance has not been studied.

In sum, current evidence indicates that texting, postural stability, and age affect driving performance. Also, there are suggestions that balance training can mediate these effects. However, the effects of these factors have not yet been examined in combination. Hence, the present study compared driving performance and perceived workload in young and older drivers both before and after a balance training (i.e., on a balance board) in four different simulated driving conditions in which texting (i.e., driving with and without texting) and sitting surface stability (i.e., driving while sitting on a stable seat and on a plastic wobble-board; see O'Sullivan et al., 2006) were manipulated. We hypothesized that texting degrades driving performance and perceived workload, and that these effects are enlarged when postural control is challenged (i.e., while sitting on an unstable surface), particularly in older adults. In addition, we expected that balance training would reduce these negative effects. We use path analysis to verify to what degree these anticipated effects are associated with postural sway.

Method

Participants

Power analysis (G*Power; version 3.1, Heinrich Heine Universitat, Dusseldorf, Germany) showed that a total of 24 participants would be sufficient to reject the null hypothesis (with $\alpha = .05$, $1 - \beta = 0.95$, $f = 0.25$). Thirteen older adults (mean age = 62.8 years, *SD* = 7.2, all male) and 15 young adults (mean age = 24.3 years, *SD* = 4.8, 11 male) volunteered to participate in this study. Only drivers with a valid driving license were recruited for this study. Prospective older participants were excluded when they had a history of falling in the past year, and/or reported that they had postural, musculoskeletal, or visual disorders, or were taking medication which would affect postural control. The younger participants were recruited from Kharazmi University (Tehran, Iran), while older adults were recruited from the local community and paid a small fee for their participation. The young adults self-reported a mean driving experience of 4.0 years and an average of 6.2 driving hours a week, while the older adults had a mean driving experience of 36.3 years and an average of 21.6 driving hours a week. With respect to texting habits, all of the younger drivers and 23% of the older drivers reported that they often were texting while driving. Participants signed written informed consent before participating, and the study was approved by the Kharazmi University Institutional Review Board.

Instrumentation

Driving simulator. The driving simulator (pride CI 302 semi) consisted of a PC with three high-resolution monitors, which provided a 145° viewing angle of the simulated environment. The simulator was also equipped with a seat, gear, steering wheel, gas, brake, and clutch pedal (Figure 1). A one-way highway scenario without any cars and turns was selected as the virtual driving environment. The driving scenario was created using 3DVIA Virtools® (Nasir driving simulator, KNT University, Iran). A cruise control system with a constant car speed of 60 km/hr was used in all conditions. To measure driving performance, the vehicle's position data were sampled in X, Y, and Z directions at 30-Hz frequency and were collected using the simulator's software.

Wii balance board. Seated postural sway was assessed using the Wii balance board (Nintendo®, Kyoto, Japan). In order to record postural sway signals accurately, the Wii balance board (i.e., 10 cm high) was embedded in a bench (i.e., 35 cm high) (Figure 1) that served as the car seat. COP position in X, Y, and Z directions was sampled at 90 Hz and transferred via Bluetooth to a laptop using custom-made software.

Wobble board. A plastic wobble board (i.e., 18-cm radius and 5-cm high) was used to destabilize sitting posture. It was placed upon the Wii balance board (Figure 1). Before starting testing, the seat height and position were adjusted manually to each participant's height to provide proper postural (de)stabilization. In the unstable sitting surface conditions, next to the wobble board, a volleyball ball (i.e., circumference = 65 cm) was also used on which participants had to rest their feet.

Figure 1 — The driving simulator and overview of the experimental setup in unstable sitting surface conditions.

Workload questionnaire. To gauge perceptions of workload, the National Aeronautics and Space Administration Task Load Index (Hart & Staveland, 1988) was used. The National Aeronautics and Space Administration Task Load Index is an indicator of combined cognitive, physical, and temporal demands of a task, and scores perceptions of mental, physical, and temporal effort and frustration from 1 (*very low*) to 20 (*very high*).

Procedure

The protocols of the balance training and driving simulation test were determined in a pilot study. The driving simulation test was performed twice, once before and once after the balance training. For the driving simulation tests, participants were asked to drive in four conditions: (a) normal driving, (b) driving plus texting, (c) driving while sitting on an unstable surface (i.e., a plastic wobble board), and (d) driving plus texting while sitting on an unstable surface. Conditions were counterbalanced among participants, but the order of conditions for the individual participants was the same before and after the balance training. The participants were sitting on the bench with the Wii balance board. Each condition took 3 min. They were told to steer along the lane's center. In the two texting conditions, participants were required to hold their personal phone in one hand and hold the steering wheel with the other hand (i.e., according to their preferences), and text for the full 3 min. They were asked to text invitations to their friends for an imaginary upcoming party and to inform them about the place and time of the party. If participants had finished texting before the end of the trial, they were told to add more information in their text (e.g., things guests should bring to the party) or invite more people. However, participants were asked to place priority on keeping the vehicle in the lane's center. In the two unstable sitting surface conditions, participants sat on the wobble board, which was placed on the bench with the Wii balance board. Participants were told not to lean on the car seat and to place their feet on the ball while driving.

The balance training consisted of a single session of 30-min training, divided in blocks of 5 min. Participants sat on a wobble balance board embedded in a chair. To challenge sitting posture maximally, participants were instructed to sit free without support, put their feet on a ball and try to maintain their balance without using their hands (i.e., they were allowed to use their hands to maintain their balance only in the case of a near fall). The training was carried out 10-min after finishing the first driving simulation test. The second driving simulation test was performed after participants had finished the training and a 10-min rest period. The perceived workload was assessed immediately after completion of each condition in both driving tests.

Data Analysis

Driving performance. The standard deviation of lane position (SDLP) is considered as one of the most common variables for driving performance, especially when the research questions are related to the impact of texting on driving (Caird et al., 2014). This variable also has good face validity that shows how stably a driver can control a car in a lane with or without disturbance or distraction. Lane position of the car is defined as a distance between the center of the vehicle and lane center (He, McCarley, & Kramer, 2014). We calculated it as follows. We presume that points $p_1^r = (x_1, y_1)$ and $p_2^r = (x_2, y_2)$ are two points on the reference trajectory, and that $p_i^v = (x_i^v, y_i^v)$ is the car's center of mass position at sample i, such that the $x_1 < x_i^v < x_2$ is as narrow as possible. It follows that the vehicle's lane position at any time i, with respect to the reference trajectory is found via:

$$d_{(i)} = \frac{|ax^v(i) + by^v(i) + c|}{\sqrt{a^2 + b^2}}$$

where

$$a = y_2 - y_1,$$

$$b = -(x_2 - x_1),$$

$$c = (x_2 - x_1)y_1 - (y_2 - y_1)x_1.$$

Accordingly, d_i represents the car's distance (in meters) or deviation from or the vehicle's position in the lane. Next, the SDLP was calculated as follows:

$$\mathrm{SD} = \sqrt{\frac{\sum_{i=1}^{N} (d_i - \overline{d})^2}{N}}$$

in which $\overline{d} = \frac{d_i}{N}$ is the mean deviation. Higher SDLP values indicate a larger variability in lane position and thus poor driving performance.

Perceived workload. Following previous work, we used the average score of the six subscales of the National Aeronautics and Space Administration Task Load Index workload questionnaire as the measure of total workload (Bahmani, Bahram, Diekfuss, & Arsham, 2019; Raisbeck, Diekfuss, Wyatt, & Shea, 2015).

Postural sway. Mean center of pressure velocity (COP-velocity) in the medial–lateral direction served as the dependent variable for postural performance, since previous studies showed this to be a sensitive measure for detecting change in balance (Era et al., 2006; Lemay et al., 2013; Masani, Vette, Abe, & Nakazawa, 2014). The mean COP-velocity (in cm/s) was calculated as follows:

$$MV = \frac{\sum_{i=2}^{N} \left| \left(\mathrm{COP}x_i - \mathrm{COP}x_{i-1} \right) \right|}{N \times dt}$$

in which dt is the time between the samples. Higher COP-velocity values indicate a larger postural sway and thus decreased postural stability.

Statistical Analysis

First, the assumption of normality was checked using Shapiro–Wilk tests. Then, separate 2 (group: young, old) × 2 (texting: with, without) × 2 (surface: stable, unstable) × 2 (test: before training, after training) analyses of variance with repeated measures on the last three factors were conducted for each of the three dependent variables (i.e., SDLP, perceived workload and COP-velocity). Post hoc tests were performed using Bonferroni adjustments. The η_p^2 were reported for effect size and considered small for $\eta_p^2 < .06$, moderate for $\eta_p^2 > .06$ and $\eta_p^2 < .14$, and large for $\eta_p^2 > .14$. Finally, two separate simple moderation analysis (PROCESS macro; model 1) were conducted to uncover whether postural sway (i.e., COP-velocity) affected participants' driving performance and perceived workload (Hayes, 2017).

Results

Driving Performance

Analysis of variance revealed significant main effect of group on SDLP, $F(1, 26) = 27.69$, $p < .001$, $\eta_p^2 = .52$, with a larger SDLP (i.e., more variable lane position) for the older drivers compared with the younger drivers. The main effect of texting was also significant, $F(1, 26) = 49.23$, $p < .001$, $\eta_p^2 = .65$, indicating that texting increased SDLP relative to driving without texting. The significant main effect of test, $F(1, 26) = 10.80$, $p < .003$, $\eta_p^2 = .29$, indicated that SDLP was significantly lower after the balance training. In addition, significant interactions of Group × Test, $F(1, 26) = 7.45$, $p = .007$, $\eta_p^2 = .25$, Group × Texting, $F(1, 26) = 19.70$,

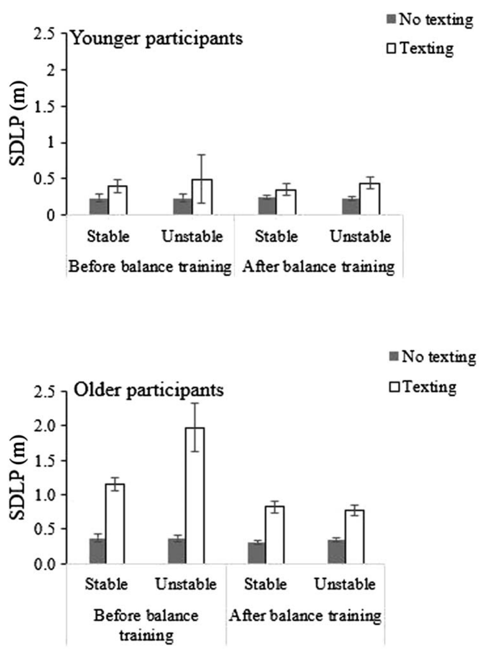

Figure 2 — The mean and *SE* of SDLP in younger participants (top) and older participants (bottom) as a function of texting and sitting surface before and after the balance training. SDLP = standard deviation of lane position.

$p < .001$, $\eta_p^2 = .43$, and Test × Texting, $F(1, 26) = 8.09$, $p = .009$, $\eta_p^2 = .24$ were revealed, but these effects were superseded by a significant interaction of Group × Texting × Test, $F(1, 26) = 05.83$, $p = .023$, $\eta_p^2 = .18$. Post hoc comparisons indicated that older drivers had larger SDLP compared with younger drivers, but only when they were texting while driving. In addition, following the balance training, the older adults (but not the younger adults) had reduced SDLP in conditions where they were texting while driving; yet, even with this reduction, the SDLP in these conditions remained higher in older than in younger drivers. The younger adults' SDLP was not reduced after training (Figure 2). Finally, there were no significant main or interaction effects for sitting surface F's$(1, 26) < 3.79$, p's $> .061$, η_p^2's $< .13$.

Perceived Workload

The main effect of group on perceived workload was not significant. However, significant effects were found for test, $F(1, 26) = 72.39$, $p < .001$, $\eta_p^2 = .74$,

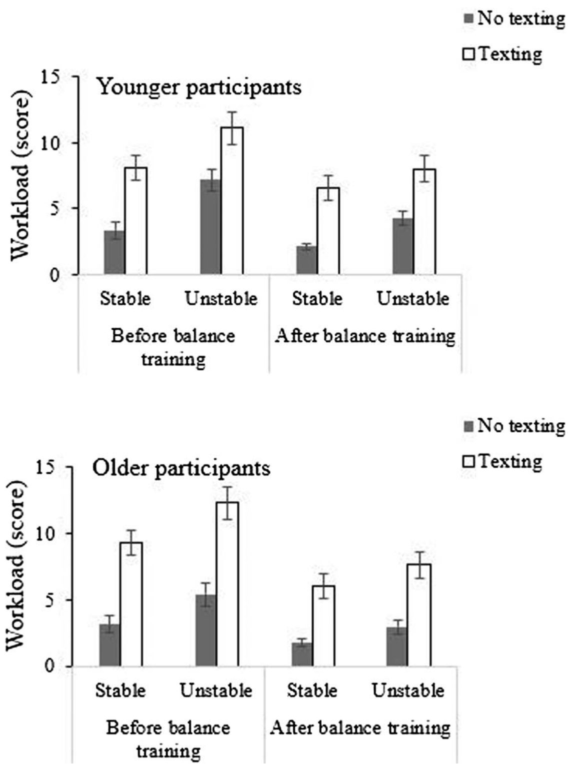

Figure 3 — The mean and *SE* of perceived workload in younger participants (top) and older participants (bottom) as a function of texting and sitting surface before and after the balance training.

texting, $F(1, 26) = 68.77$, $p < .001$, $\eta_p^2 = .73$, and the interactions of Test × Texting $F(1, 26) = 8.7$, $p = .008$, $\eta_p^2 = .24$, and Test × Texting × Group, $F(1, 26) = 4.87$, $p < .036$, $\eta_p^2 = .16$. Texting resulted in higher perceived workload than no texting, and workload was significantly reduced after training compared with before training, with largest reduction demonstrated by the older adults in the texting condition (Figure 3). Post hoc comparisons, however, failed to indicate the locations of the interactions. Finally, significant effects of surface, $F(1, 26) = 79.63$, $p < .001$, $\eta_p^2 = .75$ and Test × Surface $F(1, 26) = 8.97$, $p = .006$, $\eta_p^2 = .26$, were found. Unstable surface resulted in increased perceived workload, especially in the pretest. Post hoc comparisons indicated that all comparisons were significant, except between the stable surface in the pretest and the unstable surface in the posttest (Figure 3).

Postural Sway

For COP-velocity, the main effect of surface was significant, $F(1, 24)$[1] $= 66.83$, $p < .001$, $\eta_p^2 = .74$, with a lower COP-velocity when drivers were sitting on an unstable surface compared with stable sitting surface. The main effect of texting

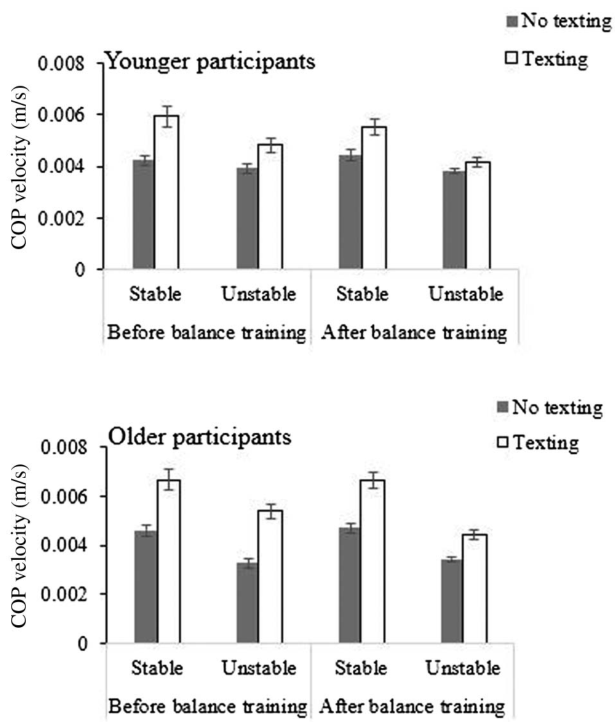

Figure 4 — The mean and *SE* of COP velocity in younger participants (top) and older participants (bottom) as a function of texting and sitting surface before and after the balance training. COP = center of pressure.

was also significant, $F(1, 24) = 84.80$, $p < .001$, $\eta_p^2 = .79$, with increased COP-velocity when texting while driving compared with driving without texting. This effect seemed most pronounced among the older adults (Figure 4). Accordingly, there was a significant Texting × Group interaction for COP-velocity, $F(1, 24) = 6.18$, $p = .02$, $\eta_p^2 = .21$. Post hoc comparisons, however, failed to reveal any significant differences. In addition, a significant Surface × Texting interaction, $F(1, 24) = 7.96$, $p = .009$, $\eta_p^2 = .25$, was found. Perhaps counterintuitively, post hoc comparisons indicated that the stable sitting surface resulted in increased COP-velocity especially in texting conditions (Figure 4). Finally, a significant Texting × Test interaction was revealed, $F(1, 24) = 13.04$, $p = .001$, $\eta_p^2 = .35$. Post hoc analyses indicated that while balance training did not affect COP-velocity for conditions without texting, it did reduce COP-velocity in conditions in which drivers were texting (Figure 4).

Moderation Analysis

Moderation analyses revealed that there were no significant direct effects of COP-velocity (i.e., postural sway) and group (i.e., age) on SDLP (i.e., driving performance). However, the significant COP-velocity × Group, $b = 1.24$, $t(208) = 2.06$, $p = .04$, indicates that effects of COP-velocity on SDLP were affected by age. While COP-velocity did not affect younger drivers' SDLP (i.e., $p > .05$), it did affect older drivers' SDLP, $b_{\text{Older drivers}} = 1.70$, $t(208) = 4.56$, $p < .001$ (Figures 5 and 6).

In addition, although the effect of COP-velocity on perceived workload was significant $b = 7.54$, $t(208) = 2.25$, $p = .025$, both the effect of age and the COP Velocity × Age interaction were not significant (Figures 7 and 8).

Discussion

In the present study, we compared older and younger drivers' driving performance and perceived workload with and without text messaging and while sitting on a stable or unstable surface both before and after a brief balance training. We also aimed to verify to what extent any effects were associated with postural control. The main findings were that participants' driving performance deteriorated with texting, especially in older participants, irrespective of the stability of the sitting surface. A brief single-session balance training improved the older adults' driving performance while texting, but not to the same level as the younger drivers. Perceived workload was clearly increased when drivers were texting compared with driving without texting. Balance training reduced perceived workload, apparently foremost among older adults that were texting. Finally, also the unstable sitting surface increased perceived workload, especially but less so after balance training. These effects on driving performance and perceived workload were (indirectly) associated with changes in postural stability.

The observation that older drivers show poorer driving performance, but did not report higher workload than younger drivers, confirms findings in previous work (Shanmugaratnam, Kass, & Arruda, 2010). In addition, there are also many studies showing age-related declines in postural control, including in driving tasks (Amiridis, Hatzitaki, & Arabatzi, 2003; Horak, Shupert, & Mirka, 1989; Lacour,

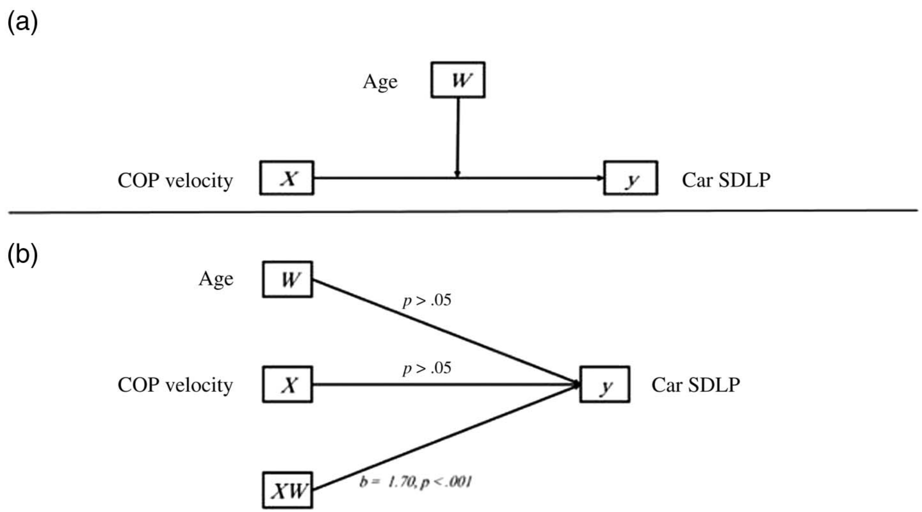

Figure 5 — (a) Conceptual and (b) statistical diagram of the effect of postural sway (COP velocity) on driving performance (SDLP) with age as moderator. SDLP = standard deviation of lane position; COP = center of pressure.

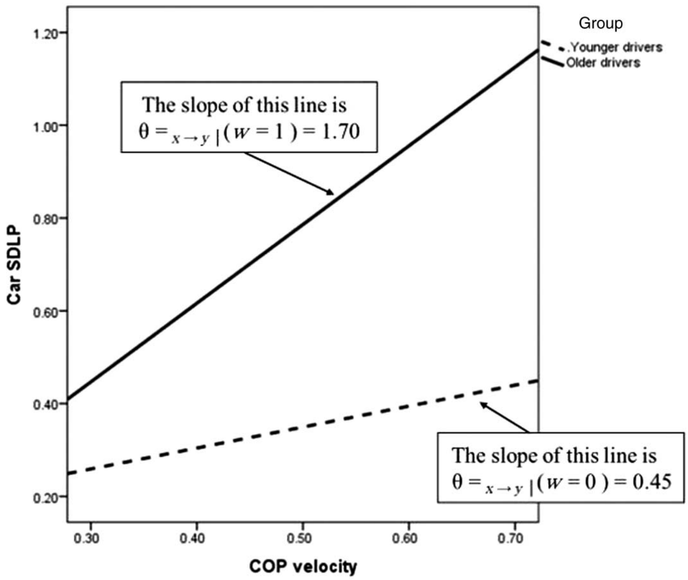

Figure 6 — The COP Velocity × Age interaction for SDLP. COP = center of pressure; SDLP = standard deviation of lane position.

Bernard-Demanze, & Dumitrescu, 2008; Woollacott, 2000). And, although we did not find a difference in postural sway between the two age groups, the path analyses did indicate that driving performance was associated with postural sway in the older drivers and not in the younger drivers (i.e., a 1 unit increase in COP-velocity induced 1.7 units increase in older adults' car SDLP). Perceived workload was associated with postural sway in both age groups. It is not straightforward from the present findings to further specify the factors underpinning the observed age-related differences in driving performance. They possibly relate to differential responses to the combined effects of texting and instability of the sitting surface.

To start with, both the younger and the older adults showed poorer driving performance and increased perceived workload when texting while driving. Indeed, we also found that texting negatively affected postural stability (i.e., increased postural sway). Typically, it is theoretically predicted that driving performance is disrupted if critical cognitive and/or physical resources for driving are concurrently involved in a second task, such as texting (Wickens, 1980). Accordingly, limited working memory capacity and/or the hands being involved in both steering and texting can underlie the observed degradation in driving while texting. A similar pattern of results was found for postural sway, which is in line with previous reports on adverse effects of dual tasking on balance control (Huxhold, Li, Schmiedek, & Lindenberger, 2006; Melzer, Benjuya, & Kaplanski, 2001; Nurwulan et al., 2015; Paloski et al., 2006; Rebold et al., 2017). The similar patterns on driving performance, perceived workload, and postural sway as a

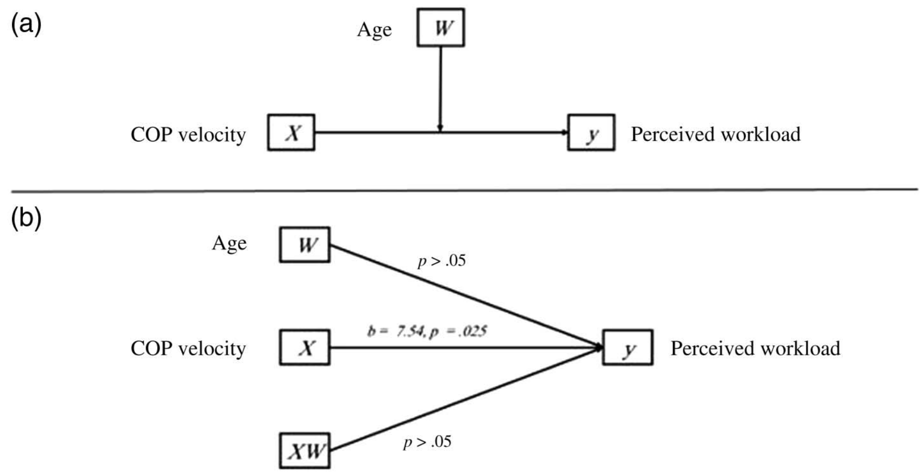

Figure 7 — (a) Conceptual and (b) statistical diagram of the effect of postural sway (COP velocity) on perceived workload with age as moderator. COP = center of pressure.

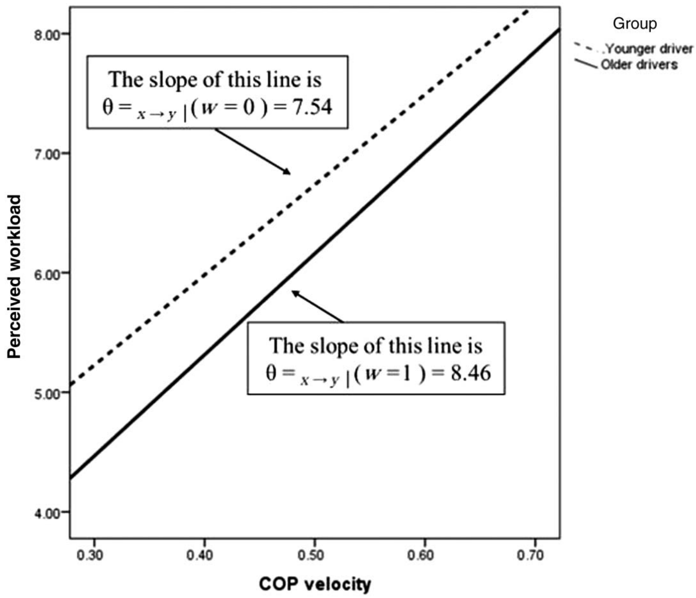

Figure 8 — The COP Velocity × Age interaction on perceived workload. *Note*. This interaction was not significant. COP = center of pressure.

function of texting in both groups, highlights that postural stability does indeed constrain driving performance and provides additional support for previous studies arguing that postural control is an influential factor for safe driving (Anstey et al., 2005; Lacherez et al., 2013). Indeed, increasing postural stability with a brief balance training did increase driving performance and decrease perceived workload while texting in both groups, although more so in older drivers. This relationship may involve shared cognitive and/or physical resources, but may also be attributed to the postural system's role in providing a stable frame of reference for perception. That is, it has been suggested that trunk instability reduces the ability to detect relevant information regarding environment dynamics necessary for vehicle control (Petersen et al., 2008). In this respect, our observations regarding the manipulation of the stability of the sitting surface with the wobble board may also be pertinent. In fact, both groups were capable of maintaining driving performance while sitting on an unstable surface, but they did report increased workload (particularly in the pretest). Intriguingly, however, the unstable sitting surface resulted in *lower* sway velocity, that is, *enhanced* postural stability. This was unexpected given that previous research reported increased sway while sitting on an unstable surface relative to sitting on a stable surface (e.g., O'Sullivan et al., 2006). Yet the increased perceived workload indicated that participants might have put additional mental effort into keeping a stable posture in trying to maintain drivng performance. This increased mental effort may have particularly benefitted postural control in conditions where stability was threatened by both an instable sitting surface and texting. Put differently, stably seated participants may not have been aware that texting increased postural sway, and thus they may not have deliberately invested in reducing it, resulting in relatively increased postural sway.

It is interesting that the brief balance training did improve overall postural stability in both groups, but that the adverse effects of text messaging on driving performance and postural stability were only reduced among the older drivers. Likely, this is due to the more pronounced effects texting had on the older drivers. This may be because they were less experienced in texting and/or because of more limited resources or capacity to combine the performance of different tasks. Because the effects of the manipulation of sitting surface stability were not reduced by the balance training, we suggest that the observed effects of texting on driving performance and postural stability were mainly due to cognitive interference, with the balance training relieving the older drivers' attention to maintaining postural control and hence reducing the negative effects of texting on driving performance. As younger drivers' cognitive resources were less challenged by texting, the balance training had no or only negligible effects on their driving performance. Nevertheless, the positive effects of balance training in older adults is an interesting finding as it suggests that including balance training in drivers' training regimes can enhance driving performance. Future research may want to investigate effects of more prolonged balance training programs on safety in driving among different populations, including younger adults.

Overall, our results confirm the adverse effects of texting on driving. The findings indicate that these negative effects are associated with age and postural stability, and that brief balance training reduces the negative effects, especially in older adults. It should be noted that our study is not without limitations. For example, our driving scenario was simple, without any cars and turns, without allowing to rest against the back of the seat, and without requiring the use of pedals during driving. While we are aware and acknowledge that these conditions are somewhat different from naturalistic driving scenarios, we decided to use this simple and artificial scenario to control other possible confounding factors. Nevertheless, our study makes an important contribution as it provides evidence that the negative effects of texting on driving performance relate to postural stability, and importantly, that even a single session of balance training may enhance postural stability and driving performance, at least in older drivers. Future studies, with more naturalistic driving conditions, more complex traffic environments, more prolonged balance training programs, and delayed retention tests would help to further understand the combined (and perhaps circular) roles of texting and postural stability in driving performance. Measuring factors such as head stability or gaze behavior may provide more plausible evidence regarding the role of postural control in driving and also, the extent to which appropriate training programs (e.g., instability balance training) can improve postural stability while driving conditions are more naturalistic (e.g., when drivers are leaning back against the seat).

Note

1. For technical reasons, parts of the COP-data of three young participants were incomplete. Consequently, the young adults' group sample size reduced to 13 for the COP data.

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