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# Large lateral head movements and postural control

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Riccio and Stoffregen (1988) have suggested that task performance is the predominant constraint of change in postural control. To test this hypothesis, 12 healthy, young adults performed large lateral gaze shifts (left/right gaze shifts with a visual angle of 150° and at a frequency of 0.5 Hz or 1 Hz) and a control condition (looking at a stationary dot). Performance in the visual task was expected to be good under all conditions. In accordance with Riccio and Stoffregen's hypothesis, the center of pressure sway variability (range or standard deviation) was expected to be similar in the three visual tasks when a destabilizing, narrow stance was adopted. Indeed, body sway had to be restrained in narrow stance to adequately perform the task. In standard and wide stance conditions, the center of pressure sway variability was expected to be larger when gaze shifts were performed. Indeed, in these more stable stance conditions, the task could be performed successfully in minimizing energy expenditure, that is, in letting body sway increase naturally. The results were consistent with these expectations. On a practical level, intentional, large gaze shifts may not cause postural instability *per se*, even though postural sway may increase significantly.



## 1. Introduction

Humans may have adopted a bipedal stance because the latter enabled them to perform suprapostural tasks (Riccio & Stoffregen, 1988; Stoffregen, Smart, Bardy, & Pagulayan, 1999) such as grasping, pulling, carrying and looking around. Hence, some authors have suggested that postural control is not a goal by itself, but a means to achieve goals (Mitra & Fraizer, 2004; Riccio & Stoffregen, 1988; Smart,

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Mobley, Otten, Smith, & Amin, 2004; Smart & Smith, 2001; Stoffregen, Bardy, Bonnet, & Pagulayan, 2006; Stoffregen, Pagulayan, Bardy, & Hettinger, 2000). Along this line, Riccio and Stoffregen (1988) have suggested that postural control is adapted to facilitate performance in one or more on-going tasks. In their hypothesis, individuals adopt "goal-directed behavior" when interacting with their environment (Riccio, 1993). Stated differently, success in the task is believed to be of primordial importance for the postural control system. For example, the performance of lateral eye movements to track predictable, small (1° of visual angle) visual targets can be undermined by high postural sway (Stoffregen et al., 2006). Hence, postural sway was expected to be reduced in these gaze shift conditions. The task performance had to be difficult enough; otherwise no change in postural sway was expected. To test the "goal-directed" hypothesis, Stoffregen et al. (2006) and Stoffregen, Bardy, Bonnet, Hove, and Oullier (2007) asked healthy, young adults to perform gaze shifts by following a dot that appeared alternately on the left and right at a visual angle of 11°. Gaze shifts were performed at 0.5 Hz (Stoffregen et al., 2006) and at 0.5, 0.8 and 1.1 Hz (Stoffregen et al., 2007). In a control visual task, the subjects looked at a stationary dot directly in front of them. As expected, the participants exhibited significantly less body sway variability (as measured by the standard deviation of center of pressure and head and torso sway) in both mediolateral (ML) and anteroposterior (AP) axes when performing gaze shifts. In these studies, the participants did not move their head during the various visual tasks and achieved good performance levels. Riccio and Stoffregen's (1988) hypothesis has since been validated with other kinds of visual task (Balasubramaniam, Riley, & Turvey, 2000; Smart et al., 2004; Stoffregen et al., 2000). Also in these studies, the visual tasks were performed well and the participants only made tiny hand, head or/and eye movements.

For large, rapid lateral gaze shifts involving the movement of heavy body segments such as the head and the trunk (Hollands, Ziavra, & Bronstein, 2004), one would expect postural sway and displacement of the body's center of mass (COM) to increase significantly. In such situations, the center of pressure (COP) would also increase significantly because COP displacement is larger than COM displacement and increase even more than COM displacement (Winter, 1995). In these conditions, does it mean that Riccio and Stoffregen's (1988) hypothesis is systematically wrong or not testable? We did not think so. In conditions with large body movements, their hypothesis could be tested and validated even if postural sway should be significantly greater than in a control condition with no intentional movement. If postural control were to be challenged by the adoption of a narrow stance position (increasing COP and postural sway, see Day, Steiger, Thompson, & Marsden, 1993; Mouzat, Dabonneville, & Bertrand, 2004), one would expect the postural sway to show similar characteristics in the large gaze shift and control conditions; success in the visual task would require the maintenance of postural stability. That is, postural sway would need to be strictly restrained to perform the task well because more sway would quickly lead to postural instability in narrow stance. In contrast, if postural control were to be made easier by placing the feet further apart than usual (i.e., wide stance), postural sway should be significantly greater in gaze shift conditions than in the control condition. It would be so if task performance is not worsened by increased postural sway. In such case, individuals would no longer need to constrain their sway as much as in narrow stance to avoid losing their energy inefficiently: Indeed, "actions that minimize movements require effort" (Riccio & Stoffregen, 1988 p. 283). A trade-off between task performance and energy expenditure would have to be adopted to keep the task performance high.

In the present study, we sought to determine whether postural control (represented by COP sway, cf., Winter, 1995) could be adjusted efficiently in order to successfully perform large, lateral gaze shifts (with a visual angle of 150° at 0.5 or 1 Hz) under different stance width conditions (narrow, standard and wide stances). In other words, our goal was to test Riccio and Stoffregen's (1988) hypothesis that task performance is the predominant constraint of change in postural control. We did so in conditions varying the difficulty of ML stance. We expected our results to be consistent with Riccio and Stoffregen's (1988) hypothesis. Gaze shifts were large and quick to ensure that COP sway variability would increase if the participants did not specifically restrain it. These gaze shifts also ensured that performance of the visual task was challenging. Overall, we expected individuals to succeed well in all visual tasks, without losing their balance. To perform the large gaze shift task efficiently in narrow stance, we expected COP sway variability to be actively controlled and thus to not increase significantly relative to the control condition (looking at a stationary dot). In contrast, COP sway variability in wide stance