

1 The Effect of Cognitive Task Type and Walking Speed on Dual-Task Gait in Healthy Adults

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1 Abstract

2 Using a dual-task gait paradigm, a number of studies have reported a relationship between
3 cognitive function and gait. However, it is not clear to what extent these effects are dependent
4 on the type of cognitive and walking tasks used in the dual-task paradigm. This study
5 examined whether stride time variability (STV) and trunk range of motion (RoM) are
6 affected by the type of cognitive task and walking speed used during dual-task gait.
7 Participants walked at both their preferred and 25% of their preferred walking speed and
8 performed a serial subtraction and a working memory task at both speeds. Both dual-tasks
9 significantly reduced STV at both walking speeds, but there was no difference between the
10 two tasks. Trunk RoM was affected by the walking speed and type of cognitive task used
11 during dual-task gait: medio-lateral trunk RoM was increased at the slow walking speed and
12 anterior-posterior trunk RoM was higher when performing the serial subtraction task at the
13 slow walking speed only. The reduction of STV, regardless of cognitive task type, suggests
14 healthy adults may redirect cognitive processes away from gait toward cognitive task
15 performance during dual-task gait.

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1 Introduction

2 There is a growing recognition amongst researchers that the control of gait may be sub-served
3 by both automatic and high-level cognitive processes (Yogev-Seligmann, Hausdorff, &
4 Giladi, 2008). The relationship between cognition and gait performance is typically examined
5 using a dual-task (DT) paradigm, where participants perform a cognitive task whilst walking.
6 Impairment of gait performance during DT gait is thought to indicate competition between
7 shared resources involved in both cognitive and gait tasks (Al-Yahya et al., 2011; Fraizer &
8 Mitra, 2008; Yogev-Seligmann et al., 2008). Researchers use DT gait studies to examine
9 differences in the relationship between cognition and gait in healthy adults and clinical
10 populations (Beauchet et al., 2003; Springer et al., 2006). Within the DT gait literature, stride
11 time variability (STV) and trunk motion are used as markers of gait automaticity and stability
12 (Gabell & Nayak, 1984; Herman, Mirelman, Giladi, Schweiger, & Hausdorff, 2010; Winter,
13 1995). Although DT gait is frequently reported to increase STV and influence trunk motion
14 in healthy adults (Asai, Doi, Hirata, & Ando, 2013; Szturm et al., 2013), others have reported
15 decreases (Lövdén, Schaefer, Pohlmeier, & Lindenberger, 2008) or no changes to STV or
16 trunk motion (van Iersel, Ribbers, Munneke, Borm, & Rikkert, 2007; Laessoe, Hoeck,
17 Simonsen, & Voigt, 2008; Springer et al., 2006). One possible cause of this discrepancy is the
18 heterogeneity in both the walking protocols and cognitive tasks used within DT gait studies,
19 which may alter the effect of the DT on gait and balance (Fraizer & Mitra, 2008; Huxhold,
20 Li, Schmiedek, & Lindenberger, 2006).

21 Cognitive task type has previously been suggested to influence the effect of the DT on gait
22 (Beauchet et al. 2005; Doi et al. 2011). A number of studies have reported that concurrent
23 performance of a serial subtraction task increases STV in healthy adults (Asai et al., 2013;
24 Beauchet, Dubost, Herrmann, & Kressig, 2005; Doi et al., 2011). In contrast, the effect of the

1 N-back working memory task on gait is less clear, with previous studies reporting either no
2 change or decreases in STV (Lövdén et al., 2008; Plummer-D'Amato et al., 2008; Schaefer,
3 Lövdén, Wieckhorst, & Lindenberger, 2010). Serial subtraction tasks are suggested to place
4 high demands on attentional processes (Ganguli, Ratcliff, & Huff, 1990) whilst the N-back
5 test is widely assumed to test working memory capacity (Jaeggi, Buschkuhl, Perrig, &
6 Meier, 2010; Owen, McMillan, Laird, & Bullmore, 2005). Thus, the serial subtraction task
7 may increase STV during DT gait because both tasks require, and compete for, shared high-
8 level attentional processes (Yogev-Seligmann et al., 2008). Conversely, Beurskens & Bock,
9 (2012) suggest that ,as the N-back test does not increase STV during DT gait (Lövdén et al.,
10 2008; Schaefer et al., 2010), the primary cognitive processes used to solve the N-back test are
11 not involved in the control of human locomotion. Therefore, differences in the cognitive
12 processes which underlie performance in both tasks may explain the reported disparity
13 between their effects on gait. Comparing a serial subtraction task and working memory task
14 may provide insight into the nature of the cognitive processes required for the control of dual-
15 task gait, however the effects of these two tasks on DT gait has not yet been investigated
16 experimentally.

17 Walking speed may also influence DT gait performance (Beauchet et al., 2009). STV is
18 higher and trunk range of motion (RoM) in the medio-lateral (ML) and anterior-posterior
19 (AP) directions is lower when walking at speeds slower than preferred walking speed
20 (Jordan, Challis, & Newell, 2007; Kavanagh, 2009). Beauchet and colleagues (2009)
21 suggested that increases in stride-to-stride variability when walking at speeds below preferred
22 walking speed may indicate a greater reliance on high-level cognitive processes. Constraining
23 the stepping pattern requires the walker to pay greater attention to foot placement, resulting in
24 increased dual task costs (Brown, McKenzie, & Doan, 2005; Sparrow, Bradshaw,

1 Lamoureux, & Tirosh, 2002). The perceived difficulty of the walking task may also influence
2 the allocation of attention during DT gait (Kelly, Eusterbrock, & Shumway-Cook, 2013;
3 Kelly, Janke, & Shumway-Cook, 2010). Slow walking may thus constrain the natural
4 stepping pattern, making gait more difficult and increasing the attention required for gait
5 performance which causes increases to STV and trunk RoM. Beauchet et al., (2009) suggest
6 that reductions in walking speed may be a confounding factor between DT gait studies,
7 making interpretation of the effects of DT gait on STV difficult. Therefore, it is important to
8 understand whether the decreasing walking speed influences the effects of DT gait
9 automaticity and stability.

10 Although there is now widespread use of DT gait paradigms to assess the relationship
11 between cognition and gait, a number of different walking speeds and cognitive tasks,
12 including N-back and serial subtraction tasks, have been used (Al-Yahya et al., 2011).
13 Differences in DT gait performance between clinical groups and healthy adults are used to
14 determine changes in the relationship between cognition and locomotion in disease and old
15 age. It is therefore important to understand the consequences of changes in walking speed and
16 the possible differences in the effects of two frequently used cognitive tasks on DT gait
17 performance. The present study had two aims:

18 Aim 1: To compare the effect of the N-back and serial subtraction cognitive tasks on DT gait.
19 Serial subtraction tasks are suggested to test attention and concentration which are thought to
20 share cognitive processes with locomotion (Beauchet, Dubost, Herrmann, et al., 2005;
21 Ganguli et al., 1990), Conversely, the N-back task primarily places demands on working
22 memory, which may not be limited in the control of locomotion (Beurskens & Bock, 2012).
23 Therefore, it was predicted that the serial subtraction task would have a greater effect on
24 STV, trunk RoM and cognitive task performance during DT gait than the N-back task.

1 Aim 2: To examine the effect of reducing walking speed on STV, trunk RoM and cognitive
2 task performance during DT gait. Because slow walking may place increased demands on
3 cognitive systems compared to walking at preferred walking speed (Beauchet et al., 2009) it
4 was predicted that walking at a slow walking speed would amplify the effects of DT on gait
5 and cognitive task performance observed at the preferred walking speed. Because task
6 difficulty is thought to influence DT gait performance (Kelly et al., 2013), we also examined
7 whether walking speed affected cognitive task performance and perceived task difficulty
8 during DT gait.

9 Methods

10 Participants

11 Following institutional ethical approval, 22 healthy adults (mean age = 22.7 ± 2.7 years) from
12 within the student body of the University of Brighton took part in this study. Exclusion
13 criteria included known gait dysfunction, neurological conditions, visual impairment and
14 contra-indications to treadmill walking. All participants were experienced in treadmill use
15 and gave written informed consent prior to participating.

16 Apparatus and tasks

17 Using a repeated measures design, participants walked on a motorised treadmill (Life fitness
18 CLST, Life Fitness, Cambridge, UK). A motorised treadmill was chosen as it allows the
19 walking speed to be controlled without participants being required to attend to their walking
20 speed (Simoni et al., 2013). Temporal gait parameters were recorded using a portable gait
21 analysis system (OPAL, APDM, Portland, USA). The system consists of three wireless body-
22 worn inertial motion sensors, each containing a triaxial accelerometer and gyroscope. Two
23 sensors were placed on the left and right shank, 4 cm superior and anterior to the malleolus,

1 the third was placed on the lumbar trunk at the L5 spinous process. The sensors transmitted
2 their data online to a wireless receiving station plugged into a portable personal computer and
3 were analysed offline using the IWALK plugin for the Mobility Lab software package
4 (APDM, Portland, USA). Heel contact for each foot was defined as the peak negative shank
5 angular velocity following mid-swing (Aminian, Najafi, Büla, Leyvraz, & Robert, 2002)
6 recorded by the shank gyroscopes (range ± 2000 °/s, sample rate 128 Hz). The time between
7 successive heel contacts with the ground of the same leg was recorded as the gait cycle.
8 Stride time (s) was recorded as the mean combined gait cycle time for both legs. Trunk
9 angular distance in both the AP and ML directions was integrated from the trunk and shank
10 gyroscope data which underwent bias removal and processing in Mobility Lab.

11 Participants walked under three different cognitive task conditions: walking only with no
12 concurrent task (WALK), walking whilst performing a serial subtractions serial subtraction
13 task (SERIAL7) and walking whilst performing a working memory task (2BACK). During
14 the WALK condition, participants were asked to “walk normally” for two minutes. A white
15 circle (4 cm in diameter) was projected against a black background, from a personal
16 computer (Aspire 5742, Acer, New Taipei City, Taiwan) onto the wall mounted projection
17 screen 350 cm from the treadmill by a ceiling mounted projector (Gt750 DLP, Optoma,
18 Watford, UK). In order to ensure gaze was controlled across trials, participants were
19 instructed to “walk normally whilst looking at the white circle” in all conditions. During the
20 SERIAL7 serial subtraction task, participants were asked to subtract in sevens starting from a
21 number between 591-595. Participants were asked to accurately count aloud as many
22 numbers as possible for 120 s. Responses were recorded using the Audio Memos software
23 package (version 3.6, Imesart, Luxembourg) on a tablet computer (iPad, Apple, Cupertino,
24 USA) and analysed off-line. During the 2BACK working memory task, a series of 50 pseudo

1 randomised letters (A-J), were projected consecutively on to the wall mounted screen. Each
2 white letter was presented against a black background for 500 ms, with an inter stimulus
3 interval of 1900 ms. If the letter on the screen matched the letter displayed two stimuli
4 previously (i.e. two back) then participants pressed a button on a handheld infrared mouse
5 (SP400, Duronic, London, UK). There were a possible 10 correct responses (20% of total
6 stimuli) in each set of 50 letters. The 2BACK task was programmed using DMDX software
7 package (University of Arizona, Arizona, USA). Differences in difficulty between walking
8 speeds and each condition were assessed in a sub-set of the participants ($n = 10$) using the
9 Borg CR10 scale (Borg, 1998), a 10 point scale which asks participants to rate the difficulty
10 of the task on a scale from 0-10

11 Experimental Procedure

12 Initially, each participant's preferred walking speed was determined by repeating the
13 following assessment four times and calculating the mean average threshold for
14 identification: starting at 2.0 km.h⁻¹, participants walked on the treadmill whilst speed was
15 increased in 0.1 km.h⁻¹ increments until the participant reported that the speed equalled their
16 preferred walking speed. Treadmill speed was then increased to 6.5 km.h⁻¹ and lowered in 0.1
17 km.h⁻¹ increments until the participant again identified their preferred speed. Subsequently,
18 participants performed SERIAL7 and 2BACK whilst stood on a stationary motorised
19 treadmill. These data were used as baseline measurements for cognitive task performance
20 (stationary). Participants then walked on the treadmill for two, six-minute stages at either
21 their preferred walking speed or at 25% of their preferred walking speed (slow walking
22 speed) in a counter balanced order. Before each stage began, participants walked for 45
23 seconds to adjust to the treadmill speed. During each six-minute stage, participants performed
24 WALK, SERIAL7 and 2BACK for two minutes each, in a counterbalanced order. In both DT

1 conditions, participants were not given any instructions on whether to prioritise cognitive task
2 or gait performance. Participants rested for 30 seconds between the different walking speed
3 conditions.

4 Data analysis

5 Two-way (speed x task) repeated measures analysis of variance (ANOVA) were used
6 separately to determine the effect of walking speed and cognitive task on the following
7 measures; STV, AP and ML trunk RoM. Where a significant effect was found, Bonferroni
8 corrected pairwise comparisons were used to determine the location of the effect. Effect sizes
9 for main effects and interactions are presented as partial eta squared (η^p) and for pairwise
10 comparisons as Cohen's d (d). Logarithmic transformations were used to normalise non-
11 gaussian data. STV was calculated as the coefficient of variation (%) of stride time. Trunk
12 RoM was calculated as the trunk angular distance (degrees) covered (in the AP and ML
13 directions) per gait cycle. For both SERIAL7 and 2BACK, the number of correct answers and
14 errors were recorded when stationary and when walking at preferred and slow walking
15 speeds. From this an error rate was determined for both tasks using the following
16 calculations:

17 SERIAL7: $(\text{number of errors}/\text{total number of answers}) * 100$

18 2BACK: $(\text{number of errors}/50) * 100$

19 Due to cognitive task and perceived difficulty data being non-parametric, differences in task
20 performance and perceived task difficulty between each walking speed (stationary, preferred
21 and slow) were examined using Friedman's ANOVA for each task. Significant effects were
22 followed up with Bonferroni corrected Wilcoxon signed rank tests. Effect sizes for significant

1 effects are presented as r . A p value of < 0.05 was considered significant. Data were
2 analysed using the SPSS software package (Version 18, IBM corp, Armonk, NY, USA).

3 Results

4 Gait analysis

5 Participants' mean preferred walking speed was 1.33 ± 0.21 m.s. Mean strides per trial and
6 stride time for both walking speeds across all task conditions are shown in Table 1.

7 The effect of cognitive task type on gait variability and trunk RoM

8 ANOVA revealed a significant effect of cognitive task on STV ($F_{(2,42)}=8.3$, $p=0.001$,
9 $\eta p=0.283$). Bonferroni corrected follow up analysis revealed that STV was higher during
10 WALK than 2BACK ($p=0.02$, $d=0.37$) and SERIAL7 ($p=0.01$, $d=0.40$) but there was no
11 difference in STV between 2BACK and SERIAL7 ($p=1.0$, $d=0.22$, Figure 1).

12 There was an effect of cognitive task on AP trunk RoM ($F_{(2,42)}=7.2$ $p=0.02$, $\eta p=0.256$) where
13 AP trunk Rom was higher SERIAL7 than during WALK ($p=0.023$, $d=0.18$) and 2BACK
14 ($p=0.022$, $d=0.20$). There was no effect of cognitive task on ML trunk RoM ($F_{(2,42)}=0.2$
15 $p=0.791$, $\eta p=0.011$).

16 Figure 1 here.

17 The effect of walking speed on gait variability and trunk RoM

18 ANOVA revealed a significant effect of walking speed on STV ($F_{(1,21)}=653.4$, $p<0.001$,
19 $\eta p=0.969$) where STV was higher at the slow walking speed than at preferred walking speed.

20 There was no significant interaction between walking speed and cognitive task type on STV
21 ($F_{(2,42)}=1.0$, $p=0.388$, $\eta p=0.044$).

22 Figure 2 here

1 There was no effect of walking speed on AP trunk RoM ($F_{(1,21)}=1.0$, $p=0.324$, $\eta p=0.046$)
2 However there was a speed by task interaction ($F_{(2,42)}=8.4$ $p=0.01$, $\eta p=0.285$, see Figure 2A)
3 where AP trunk RoM was higher during SERIAL7 than WALK ($p=0.01$, $d=0.69$) and
4 2BACK ($p = 0.01$, $d=0.73$) at the slow walking speed only. There was an effect of walking
5 speed on ML trunk RoM ($F_{(1,21)}=27.9$, $p<0.001$, $\eta p=0.570$) where trunk RoM was higher at
6 the slow walking speed than at the preferred walking speed (Figure 2b). There was also an
7 interaction between walking speed and cognitive task type on ML trunk RoM ($F_{(2,42)}=5.6$,
8 $p=0.007$, $\eta p=0.211$). However, Bonferroni corrected pairwise comparison revealed that there
9 were no statistically significant differences in ML trunk RoM between SERIAL7, 2BACK
10 and WALK at either speed (all $p>0.05$).

11 Cognitive task performance and perceived task difficulty

12 Mean cognitive task performance data are presented in Table 2. The Friedman's ANOVA
13 revealed no significant effect of walking condition on SERIAL7 task performance ($X^2_{(2)} = 1.2$
14 $p=0.53$). There was also no difference between the effect of each walking conditions on the
15 2BACK test performance ($X^2_{(2)}=4.6$, $p=0.10$).

16 Table 2 here

17 There was a significant effect of walking speed on SERIAL7 perceived task difficulty
18 ($X^2_{(2)}=9.9$, $p=0.007$). Perceived difficulty was higher during walking at the slow walking
19 speed compared to walking at preferred walking speed ($T=41.0$, $r=0.52$). There was no effect
20 of walking condition on perceived difficulty of the 2BACK task ($X^2_{(2)}=0.64$, $p=0.73$).

21 Discussion

22 In the present study the effects of cognitive task type and walking speed on DT gait were
23 examined. Whilst both the serial subtraction and N-back tasks reduced STV, there was no

1 difference in the size of this reduction between the tasks. As expected, STV was higher at the
2 slow walking speed and there was a significant interaction between walking speed and
3 cognitive task on trunk RoM, where the serial subtraction task increased AP trunk RoM when
4 walking at the slow speed only. These findings suggest that the control of gait is shared by
5 cognitive systems sub-serving both serial subtraction and N-Back working memory tasks in
6 healthy adults. These results also indicate that trunk RoM is affected by both the walking
7 speed and cognitive task type used during DT gait.

8 In the present study, both cognitive tasks reduced STV of gait and, in contrast to our
9 predictions, were not different from each other. Whilst performance of a concurrent serial
10 subtraction task during gait has previously been shown to increase STV (Beauchet, Dubost,
11 Herrmann, et al., 2005), N-Back working memory tasks have been reported to reduce STV
12 (Lövdén et al., 2008; Schaefer et al., 2010). This has led some to suggest that the cognitive
13 processes required to perform the N-back test are not shared with the control of gait
14 (Beurskens & Bock, 2012). The present results do not support this suggestion, because both
15 the working memory and serial subtraction tasks reduced STV. Lövdén et al., (2008)
16 suggested that reduced STV during DT gait indicates the adoption of a smoother, automatic
17 gait pattern, which may occur because the performance of a concurrent DT redirects attention
18 away from gait to the cognitive task. The present findings support the suggestion that
19 performance of a cognitive task, regardless of task type, may redirect high-level cognitive
20 processes away from gait toward the cognitive task.

21 Previous researchers have reported that STV was negatively related to performance in tests of
22 executive function, and suggested this indicated that the maintenance of steady walking
23 requires input from cognitive and attentional processes, perhaps to allow the walker to adapt
24 to perturbations (Beauchet et al., 2012; Hausdorff, Yogev, Springer, Simon, & Giladi, 2005).

1 The present findings support this suggestion, and add to the growing body of evidence which
2 links the control of gait to high level cognitive processes and attention. However, the
3 reduction in STV in the present study are in contrast to a number of previous studies which
4 have reported increased STV during DT gait (Asai et al., 2013; Beauchet, Dubost, Herrmann,
5 et al., 2005; Beauchet et al., 2009; Kavanagh, 2009). Whilst those previous studies utilised
6 over-ground walking protocols, the present study utilised a treadmill walking protocol. A
7 reduction in STV during DT gait was also reported in two other studies that used treadmill
8 walking (Lövdén et al., 2008; Schaefer et al., 2010). Therefore, although speculative, it is
9 possible that the disparity between the results of this study and those of previous studies
10 which reported increased in STV during DT gait may be explained by the differences in
11 walking modality. Treadmill walking leads to locomotion without the individual moving
12 through the environment, which may reduce the need to assess the walk-ability of the
13 environment and encourage participants to focus attention away from walking performance,
14 Indeed, Simoni et al., (2013) have reported that over-ground and treadmill walking modalities
15 differently influence STV and cognitive task performance during DT gait. The biomechanical
16 differences between over-ground and treadmill walking, which include reduced knee and hip
17 range of motion, reduced peak breaking ground reaction force and differences in muscle
18 activation patterns, have been well described (Lee & Hidler, 2008; Riley, Paolini, Della
19 Croce, Paylo, & Kerrigan, 2007). However, less is known about the possible effects of each
20 walking protocol on cognitive load and this maybe a possible topic for future research.

21 In the present study, walking at a slow walking speed increased STV, as reported previously
22 (Beauchet et al., 2009; Jordan et al., 2007). Beauchet et al. (2009) suggested that changes to
23 STV when walking at slow walking speeds may be caused by either increased cognitive
24 involvement or other, biomechanical, factors. If the increased STV during slow walking was

1 due to a greater demand on cognitive processes during gait, then one would expect the effects
2 of the DTs on gait to be different across the walking speeds. Because the effect of both
3 cognitive tasks on STV was not different at either walking speed, our findings suggest that
4 factors other than an increased demand on cognitive processes lead to increased STV during
5 slow walking, such as changes to the walkers biomechanics (Dubost et al., 2006).

6 There was a significant interaction effect between walking speed and task type on AP trunk
7 RoM, where AP trunk RoM was higher during performance of SERIAL7 than during either
8 2BACK or WALK at the slow walking speed. Previous DT gait research has been based on
9 the assumption that changes to gait performance during DT gait indicate competition between
10 the cognitive and gait tasks for shared high-level cortical processes (Yogev-Seligmann et al.,
11 2008). One interpretation of these findings is that trunk stabilisation during slow walking may
12 be dependent on high-level processes shared with the serial subtraction task. Whilst the N-
13 back test examines working memory performance, the serial subtraction task is suggested to
14 test attention and concentration (Ganguli et al., 1990) and thus the present results suggest that
15 the control of trunk stabilisation during slow walking also requires attention.

16 The difficulty of the dual task is also suggested to influence DT gait performance (Brown et
17 al., 2005; Kelly et al., 2013). In the present study walking speed influenced perceived task
18 difficulty: participants found serial subtraction task performance during DT gait at the slow
19 walking speed more difficult than during the preferred walking speed, which may have
20 resulted in the different effects of the tasks in trunk RoM at the slow speed. The perceived
21 difficulty during DT gait at the slow walking was still only moderately difficult (Borg, 1998).
22 It is possible that the use of a treadmill to constrain the walking speed did not present a
23 challenging enough walking condition to moderate the effect of the DT on STV.

1 The response modality of our cognitive tasks were different. Armieri, and colleagues (2009)
2 reported that articulated responses in a digit span working memory task increased the DT cost
3 on gait compared to silent rehearsal of the answers. Here, the serial subtraction task required
4 responses to be articulated, whilst the N-back task required button presses in response to
5 relevant stimuli. These differences may thus have resulted in the tasks engaging different
6 processes and be responsible for the differing effects on trunk RoM. We consider this
7 explanation unlikely because one would expect these differences in trunk ROM to be present
8 at both treadmill speeds, however, they were only seen at the slow speed. Previously,
9 Huxhold et al., (2006) reported that it is the relative task difficulty and level of attention paid
10 to the task, rather than the nature of the response, that effects postural control during dual-
11 task performance and the results of the present study support this suggestion.

12 In conclusion, here stride time variability was reduced during dual task-gait, but neither
13 walking speed nor cognitive task type mediated this effect. This result indicates that during
14 dual-task gait, the performance of a concurrent cognitive task may reduce the input from
15 high-level cognitive processes for the control of gait, regardless of the nature of either the
16 cognitive task or walking speed. Trunk range of motion increased during performance of a
17 serial subtraction task, but not during an N-back working memory task, at the slow walking
18 speed only suggesting both walking speed and cognitive task type may effect trunk RoM
19 during dual-task gait. Because cognitive task type and walking speed changes some aspects
20 of DT gait, researchers should consider the way in which these variables effect gait when
21 designing DT gait studies and when interpreting the effect of the DT used on gait.

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8

1 Tables

Table 1. Mean \pm SD number of strides and stride time (seconds) across the preferred and slow walking speeds for all task conditions

	Walking speed					
	Preferred			Slow		
	Task					
	WALK	SERIAL7	2BACK	WALK	SERIAL7	2BACK
Strides	108.7 \pm 8.0	109.3 \pm 7.7	111.1 \pm 8.6	53.8 \pm 7.9	54.7 \pm 8.4	56.6 \pm 7.1
Stride Time (s)	1.08 \pm 0.08	1.07 \pm 0.08	1.07 \pm 0.08	2.16 \pm 0.29	2.12 \pm 0.32	2.09 \pm 0.25

2

3 Table 2. Mean \pm SD error rate (%) and difficulty (Borg CR10 scale) in both the SERIAL7
4 and 2BACK tasks across the three walking conditions (stationary, preferred walking speed
5 and slow walking speed)

Task		Walking speed		
		Stationary	Preferred	Slow
SERIAL7	Error rate (%)	8.2 \pm 7.9	8.2 \pm 7.4	7.6 \pm 10.2
	Difficulty (CR10)	3.9 \pm 1.6	3.1 \pm 1.5	4.1 \pm 2.8**
2BACK	Error rate (%)	6.8 \pm 7.1	6.9 \pm 7.9	5.7 \pm 6.9
	Difficulty (CR10)	3.5 \pm 2.6	3.5 \pm 2.3	3.5 \pm 2.8

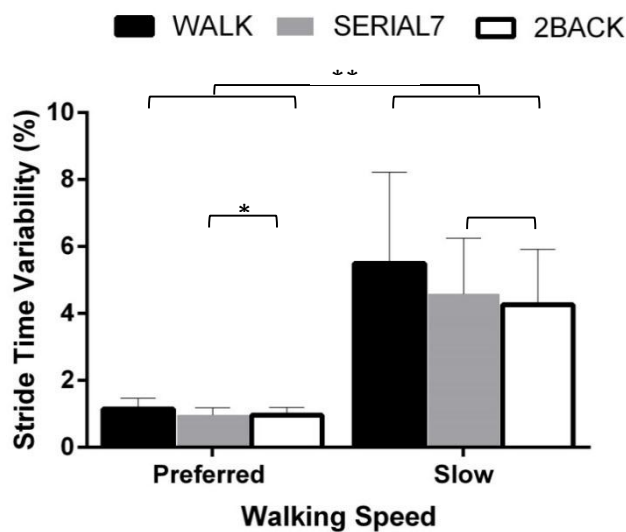
** represents a significant difference between slow and preferred walking speed ($p < 0.01$)

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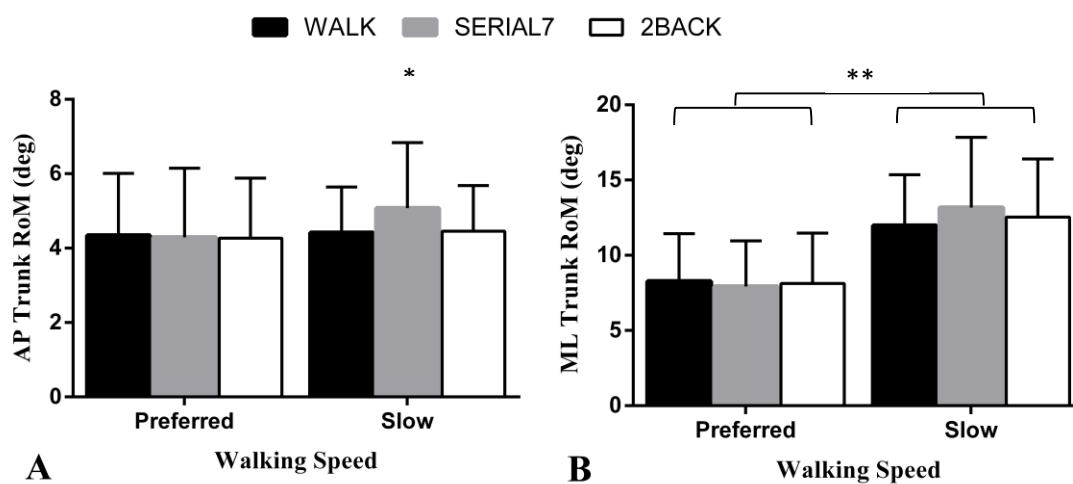
Figures



2

3 Figure 1. Mean + SD (error bars) stride time variability. * represents significantly lower stride time
 4 variability ($p < 0.05$) during SERIAL7 and 2BACK compared to WALK across both speeds and **
 5 represents significantly lower stride time variability ($p < 0.01$) at the preferred walking speed
 6 compared to the slow walking speed.

7



8

9 Figure 2. Mean + SD (error bars) anterior-posterior (AP graph A) and medio-lateral (ML
 10 graph B) trunk range of motion. * represents significantly higher ($p < 0.05$) AP trunk RoM
 11 during SERIAL7 than during WALK and 2BACK at the slow walking speed only. **
 12 represents significantly higher ML trunk RoM at the slow walking speed compared to the
 13 preferred walking speed

14