VISUAL FLOW DOES NOT ALTER MUSCLE ACTIVITY DURING TREADMILL WALKING OR RUNNING

Randall L. Jensen[1], Logan A. Zueger[2], Brenna J. Sellman[1], Pierfrancesco Scatena[3], and Mitchell L. Stephenson[4]

School of Health & Human Performance, Northern Michigan University, Marquette, MI USA[1]
Marquette Senior High School, Marquette, MI USA[2]
University of Perugia, Perugia, Italy[3]
Department of Kinesiology, Iowa State University, Ames, IA USA[4]

The current study examined the effect of visual flow (patterns of visual movement of surroundings) on muscle activity during treadmill walking and running. Participants (n=14 walked (1.39 m·s^{-1}) and ran (2.78 m·s^{-1}) in visual flow and control conditions. Activity of the *vastus medalis* (VM), *biceps femoris* (BF), *gluteus maximus* (GM), *gastrocnemius* (GA), *tibialis anterior* (TA), *erector spinae* (ES), *rectus abdominis* (RA), and *C4 paraspinal* (C4) were assessed via electromyography (EMG) during each condition. Repeated Measures ANOVA revealed EMG differences ($p < 0.05$) between walking and running for RA, VM, GM, and BF. There were no differences in speeds for the other muscles, or across the visual conditions for any of the muscles. Visual flow does not alter muscle activity during walking or running.

KEY WORDS: perception & action; peripheral effect; electromyography

INTRODUCTION: Treadmill locomotion (TM) has often be used as a training and/or research modality to examine overground locomotion. However TM, via either running or walking, has been shown to differ from overground locomotion (van Ingen Schenau, 1980; Frishberg, 1983; Lee & Hidler, 2008; Mooses, Tippi, Mooses, Durussel, & Mäestu, 2015). Thus the use of TM as a replacement for overground locomotion has been questioned. The cause of the difference has been theorized to involve visual and auditory feedback (van Ingen Schenau, 1980; Reiser, Pick, Ashmead, & Garing, 1995; Hashiba, 1998; Kong, Koh, Tan, & Wang, 2012) and resulting changes in muscle activity (Lee & Hidler, 2008).
Visual flow refers to information obtained visually for self-motion and may provide the illusion of moving; thus it has been used as a means of adjusting locomotion (Mohler, Thompson, Creem-Regehr, Pick, & Warren, 2007). Visual feedback has been noted to be important in controlling posture during both static and dynamic situations (Hashiba, 1998; Derave, Tombeux, Cottyn, Pannier, & De Clercq, 2002; Brandt, 2003). Because visual flow can be used to alter movement, it was hypothesized to result in altered muscle activity during TM walking/running. However, the current authors are unaware of any research that has examined this question. Therefore, the purpose of the current study was to examine the effects of visual flow on muscle activity during TM walking and running.

METHODS: Fourteen participants (10 females, 4 males, Mean ± SD Age = 22.1 ± 4.1 years; stature 169.6 ± 8.9 cm; mass = 67.0 ± 12.0 kg) walked at 1.39 m·s^{-1}; then ran at 2.78 m·s^{-1}. Each speed consisted of two, 5 minute trials at a grade of 1% (Jones & Doust, 1996), one as a visual flow condition and one as a control. Walking trials always preceded running, while visual flow conditions were randomly assigned. All experimental procedures were reviewed by the Institutional Review Board (HS13-560) and the participants completed an informed consent and Physical Activity Readiness-Questionnaire before data were collected.
A visual flow pattern of moving along a local street was projected onto three, 2.5m x 2.5m, rear projection screens located 1.5m in front and to either side of the participant. The design of the visual flow pattern at a speed comparable to the TM speed was chosen to elicit the illusion of walking/running with the scenery moving past the participant on the sides and toward them from the front.

Muscle activity was assessed via electromyography (EMG) of the *vastus medialis*, *biceps femoris*, *gluteus maximus*, *gastrocnemius*, *tibialis anterior*, *erector spinae*, *rectus abdominis*, and *C4 paraspinal*. All EMG sites were prepared in the same manner; the selected location was shaved if necessary, abraded, and cleaned with an alcohol pad to reduce skin impedance to < 5 kiloohms. Participants were then fitted with Noraxon Dual Electrodes (Product #272 Noraxon USA; Scottsdale, AZ) and surface EMG probes (BTS FreeEMG 300, BTS Bioengineering Corp., Brooklyn, NY) placed on the belly of the muscles according to Cram and coworkers (Cram et al., 1997). Raw data were band pass filtered at 10-450 Hz, full wave rectified, and integrated with a 50 ms moving window (BTS EMG Analyzer, BTS Bioengineering Corp., Brooklyn, NY). Muscle activity was determined by averaging five cycles of muscle activity with the onset and offset of muscle activity determined by the activation threshold; defined as two standard deviations above the mean baseline signal at rest (Jensen Leissring & Stephenson, 2015).

A Two Way Repeated Measures ANOVA (Speed X Visual Condition) using SPSS version 23, was performed to compare EMG of the muscles studied. Each specific muscle was compared to itself across the conditions for each participant. All comparisons were made at $p = 0.05$ level. A Greenhouse-Geiser correction factor was used when the assumption of sphericity was violated.

RESULTS: Significant differences in the muscle activity between walking and running were found for the *vastus medialis*, *biceps femoris*, *gluteus maximus*, and *rectus abdominis* ($p < 0.05$), while other muscles did not differ (see Table 1). There were no differences in EMG across the control/visual flow condition for any of the muscles ($p > 0.05$); neither were there any significant interactions for speed versus visual condition ($p > 0.05$) for any of the muscles.

Table 1. Mean (±SD) muscle activity (mv) for walking and running with and without Visual flow (n = number of participants assessed for that muscle).

	Walk Control	Walk Flow	Run Control	Run Flow	(n)
Rectus Abdominus *	0.004618 (0.003482)	0.004827 (0.004055)	0.018261 (0.016295)	0.011381 (0.011584)	10
Vastus Medialis *	0.014591 (0.010697)	0.016799 (0.001169)	0.048155 (0.025389)	0.046418 (0.025762)	11
Tibialis Anterior	0.023739 (0.008885)	0.020151 (0.001118)	0.044229 (0.025018)	0.049636 (0.023863)	6
C4 Paraspinal	0.006435 (0.007053)	0.006503 (0.000784)	0.019873 (0.022577)	0.025177 (0.037755)	9
Erector Spinae	0.005943 (0.003266)	0.005658 (0.002376)	0.036267 (0.060030)	0.037033 (0.058685)	9
Gluteus Maximus *	0.011034 (0.008846)	0.007433 (0.004871)	0.015214 (0.009081)	0.015026 (0.007558)	7
Biceps Femoris *	0.009632 (0.005290)	0.011034 (0.005795)	0.030450 (0.009870)	0.032098 (0.016495)	9
Gastrocnemius	0.016117 (0.003913)	0.016467 (0.006570)	0.061123 (0.091428)	0.063083 (0.008296)	6

* Significant difference between Walking and Running at the 0.05 level.

DISCUSSION: The main finding of the current study was that muscle activity, as assessed via EMG, was not affected during walking or running with visual flow. Previous authors have reported that visual flow influences the speed at which an individual changes from walking to

running (Mohler et al., 2007) and balance following walking or running (Hashiba, 1998; Derave et al., 2002). Lee and Hidler (2008) have shown a difference in muscle activity between TM and overground walking for *vastus medialis*, *biceps femoris*, and *tibialis anterior*. They suggested that individuals altered muscle activity to achieve similar movement patterns. Because balance and locomotion speeds are both controlled by alterations of muscular contractions, it was hypothesized that muscular activity might also change between the visual flow and control conditions; however, this was not the case for the muscles examined in the current study. Reiser and colleagues (1995) suggest that other environmental factors (e.g. the sound of wind), biomechanical, and other proprioceptive feedback may also alter movement. Virtual reality goggles were considered rather than the screens used in the current study; however, it was felt that the size and weight would result in mechanical loading that would alter gait in and of themselves. Therefore screens were used in the current study.
Muscle activity was increased for running when compared to walking for the *vastus medialis*, *biceps femoris*, *gluteus maximus*, and *rectus abdominis* muscles. For the remaining muscles studied, a tendency toward greater activity was present during running, but the large degree of variability likely obscured any difference (see Table 1). An increase in muscle activity during running is in agreement with previous research (Kyröläinen, Komi, & Belli, 1999; Jensen et al., 2015) and would be expected based on the increase in required force production during running (Kyröläinen et al., 1999).

CONCLUSION: The lack of differences in EMG between the visual flow and control conditions indicates that this aspect of visual information does not alter muscle activity when walking or running on a treadmill. As such differences identified between TM and overground running are likely due to other factors such as auditory, biomechanical, and/or proprioceptive feedback. Therefore it might be of interest to compare the effect of virtual reality goggles to screens and to overground locomotion to see if there are differences. In addition, further research regarding the cognitive effects/stimulation of normal treadmill walking/running vs. visual flow walking/running should be investigated.

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