Barefoot running does not affect simple reaction time: An exploratory study

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Background. Converging evidence comparing barefoot (BF) and shod (SH) running highlights differences in foot-strike patterns and somatosensory feedback, among others. Anecdotal evidence from SH runners attempting BF running suggests a greater attentional demand may be experienced during BF running. However, little work to date has examined whether there is an attentional cost of BF versus SH running.

Objective. This exploratory study aimed to examine whether an acute bout of BF running would impact simple reaction time (SRT) compared to SH running, in a sample of runners naïve to BF running.

Methods. Eight male distance runners completed SRT testing during 10 minutes of BF or SH treadmill running at 70% maximal aerobic speed (17.9 ± 1.4 km h^{-1}). To test SRT, participants were required to press a hand-held button in response to the flash of a light bulb placed in the center of their visual field. SRT was tested at 1-minute intervals during running. BF and SH conditions were completed in a pseudo-randomized and counterbalanced crossover fashion. SRT was defined as the time elapsed between the light bulb flash and the button press. SRT errors were also recorded and were defined as the number of trials in which a button press was not recorded in response to the light bulb flash.

Results. Overall, SRT later in the exercise bouts showed a statistically significant increase compared to earlier ($p < 0.05$). Statistically significant increases in SRT were present at 7 minutes versus 5 minutes (0.29 ± 0.02 s vs. 0.27 ± 0.02 s, $p < 0.05$) and at 9 minutes versus 2 minutes (0.29 ± 0.03 s vs. 0.27 ± 0.03 s, $p < 0.05$). However, BF running did not influence this increase in SRT ($p > 0.05$) or the number of SRT errors (17.6 ± 6.6 trials vs. 17.0 ± 13.0 trials, $p > 0.05$).

Discussion. In a sample of distance runners naïve to BF running, there was no statistically significant difference in SRT or SRT errors during acute bouts of BF and SH running. We interpret these results to mean that BF running does not have a greater attentional cost compared to SH running during a SRT task throughout treadmill running. Literature suggests that stride-to-stride gait modulation during running may occur predominately via mechanisms that preclude conscious perception, thus potentially attenuating effects of increased somatosensory feedback experienced during BF running. Future research should explore the present experimental paradigm in a larger sample using over-ground running trials, as well as employing different tests of attention.

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16   **Abstract**

17   **Background.** Converging evidence comparing barefoot (BF) and shod (SH) running highlights

18   differences in foot-strike patterns and somatosensory feedback, among others. Anecdotal

19   evidence from SH runners attempting BF running suggests a greater attentional demand may be

20   experienced during BF running. However, little work to date has examined whether there is an

21   attentional cost of BF versus SH running. **Objective.** This exploratory study aimed to examine

22   whether an acute bout of BF running would impact simple reaction time (SRT) compared to SH

23   running, in a sample of runners naïve to BF running. **Methods.** Eight male distance runners

24   completed SRT testing during 10 minutes of BF or SH treadmill running at 70% maximal

25   aerobic speed (17.9 ± 1.4 km h^{-1}). To test SRT, participants were required to press a hand-held

26   button in response to the flash of a light bulb placed in the center of their visual field. SRT was

27   tested at 1-minute intervals during running. BF and SH conditions were completed in a pseudo-

28   randomized and counterbalanced crossover fashion. SRT was defined as the time elapsed

29   between the light bulb flash and the button press. SRT errors were also recorded and were

30   defined as the number of trials in which a button press was not recorded in response to the light

31   bulb flash. **Results.** Overall, SRT later in the exercise bouts showed a statistically significant

32   increase compared to earlier ($p < 0.05$). Statistically significant increases in SRT were present at

33   7 minutes versus 5 minutes (0.29 ± 0.02 s vs. 0.27 ± 0.02 s, $p < 0.05$) and at 9 minutes versus 2

34   minutes (0.29 ± 0.03 s vs. 0.27 ± 0.03 s, $p < 0.05$). However, BF running did not influence this

35   increase in SRT ($p > 0.05$) or the number of SRT errors (17.6 ± 6.6 trials vs. 17.0 ± 13.0 trials, p

36   > 0.05). **Discussion.** In a sample of distance runners naïve to BF running, there was no

37   statistically significant difference in SRT or SRT errors during acute bouts of BF and SH

38   running. We interpret these results to mean that BF running does not have a greater attentional

39   cost compared to SH running during a SRT task throughout treadmill running. Literature

40   suggests that stride-to-stride gait modulation during running may occur predominately via

41   mechanisms that preclude conscious perception, thus potentially attenuating effects of increased

42   somatosensory feedback experienced during BF running. Future research should explore the

43   present experimental paradigm in a larger sample using over-ground running trials, as well as

44   employing different tests of attention.

Background

46   Despite a considerable amount of research focusing on footwear's role in injury

47 prevention (Gallant & Pierrynowski, 2014), injury rates have remained constant over the past 40

48 years (Lieberman, 2012). Approximately 85% of runners experience running-related

49 musculoskeletal injuries throughout their running career, and 30-70% of runners are treated for

50 these injuries annually (Nielsen, Buist, Sorensen, Lind, & Rasmussen, 2012). This high

51 prevalence of running-related injuries has led to investigations into the mechanisms contributing

52 to their etiology (Hreljac, 2005), and to alternative solutions beyond the classic recommendation

53 of a change in footwear characteristics. In this context, barefoot (BF) running has been proposed

54 as an alternative solution (Murphy, Curry, & Matzkin, 2013), and has gained substantial traction

55 in the public (Hryvniak, Dicharry, & Wilder, 2014). Indeed, recent literature describes several

56 distinct differences between shod (SH) and BF running. Of interest are changes in foot-strike

57 patterns (Divert, Baur, Mornieux, Mayer, & Belli, 2005; Lieberman et al., 2010; Squadrone &

58 Gallozzi, 2009), movement kinematics (Squadrone & Gallozzi, 2009), and muscle activation

59 (Snow, Basset, & Byrne, 2016; von Tscharner, Goepfert, & Nigg, 2003).

60   BF running has been promoted as a method to increase foot plantar sensation (Robbins,

61 Gouw, & Hanna, 1989; Robbins, Gouw, McClaran, & Waked, 1993; Robbins & Hanna, 1987),

62 feedback that is believed to be masked during SH running (Robbins et al., 1993; Robbins,

63 Waked, & McClaran, 1995). Improved plantar sensory feedback associated with BF running has

64 been suggested to modify kinematic variables (e.g., stride length, stride frequency) in a way that

65 ultimately alters foot-strike patterns (Daoud et al., 2012; Lieberman, 2012) to reduce plantar pain

66 and the risk of injury due to repetitive impact (e.g., during SH running with a heel-to-toe foot-

67 strike; Lieberman et al., 2010). Given running involves chronic repetitive movement, it is no

68 surprise that kinematic differences in the running gait can greatly impact one's risk of injury

69 (Daoud et al., 2012; Hreljac, 2005). Furthermore, running is associated with a high risk of acute

70 injury due to trips, falls, and sprains (Hsu, 2012; Knobloch, Yoon, & Vogt, 2008); thus, the

71 prevalence of both acute and chronic injuries in running demonstrate that efficient cognitive

72 processing and rapid reaction to perturbations or obstacles is imperative during running.

73   Prior work has suggested that the speed of basic information processing is a valid

74 indicator of higher cognitive function (Kail & Salthouse, 1994; Woods, Wyma, Yund, Herron, &

75 Reed, 2015), and that decrements in higher-order cognitive operations can be reflected by

76 diminished performance in simple tasks evaluating the speed of processing (Kail & Salthouse,

77 1994; Woods et al., 2015). Simple reaction time (SRT) is a task frequently used to measure

78 speed of processing (Woods et al., 2015). Tests of SRT often involve making a physical response

79 (e.g., pressing a button) to the presentation of a visual stimulus (e.g., light bulb flash). SRT is

80 thus defined as minimum amount of time needed to respond to the stimulus (Woods et al., 2015).

81 Furthermore, when an SRT task is simultaneously combined with another demanding situation

82 (e.g., exercise), it causes a dual-task situation (Watanabe & Funahashi, 2017). In the dual-task,

83 poorer performance often results in one or both tasks, relative to when they are preformed alone

84 (Watanabe & Funahashi, 2017). This dual-task interference effect has been established as an

85 important indicator of humans' limited capacity for information processing (Watanabe &

86 Funahashi, 2017). Past evidence has demonstrated that concurrent acute exercise can result in

87 decrements in performance on SRT tasks (Brisswalter, Arcelin, Audiffren, & Delignières, 1997;

88 McMorris & Keen, 1994). For example, a dual-task interference effect was observed during

89 rhythmic exercise when a non-preferred foot cadence was adopted (Brisswalter, Durand,

90 Delignieres, & Legros, 1995; Collardeau, Brisswalter, & Audiffren, 2001). This evidence

91   suggests that maintaining a novel stride frequency requires considerable attention, sufficient to

92   cause participants' SRT performance to deteriorate. If a non-preferred stride frequency can alter

93   SRT, then SRT could also be compromised during BF running, which promotes greater stride

94   frequency (Divert et al., 2005) and sensory feedback that causes participants to pay more

95   attention to their foot-strike (Abernethy, Hanna, & Plooy, 2002; Brisswalter et al., 1995; Hanson,

96   Whitaker, & Heron, 2009). In line with this idea, a recent study suggested that BF running

97   requires a greater level of attention than SH, due to a greater need to focus on placing footfalls

98   on the ground (Alloway, Alloway, Magyari, & Floyd, 2016).

99   The literature also indicates that individuals with worse reaction time performance are

100 prone to increased ankle instability (Konradsen & Ravn, 1990, 1991), and may be at a greater

101 risk of falls (Richardson, Exkner, Allet, Kim, & Ashton-Miller, 2017) and acute lower-limb

102 injuries such as ankle sprains (Beynnon, Renström, Alosa, Baumhauer, & Vacek, 2001; Murphy

103 & Connolly, 2003; Willems et al., 2005). Thus, given the greater sensory feedback associated

104 with BF running (Robbins et al., 1989; Robbins & Hanna, 1987), it is possible that BF running

105 requires a greater attentional demand relative to SH running, potentially leading to decrements in

106 SRT and increased acute injury risk due to sprains, collisions, stumbles, or falls.

107   Therefore, the purpose of the present study was to determine if an acute bout of BF

108 running influenced SRT compared to SH running, in a sample of competitive distance runners

109 naïve to BF running. We hypothesized that SRT would be increased during BF running, relative

110 to SH running at a similar exercise intensity.

111   **Materials & Methods**

112   This study was approved by the Interdisciplinary Committee on Ethics in Human

113 Research at the Memorial University of Newfoundland (ethics approval number: 20130246-HK),

114   with informed consent being gathered in accordance with the principles outlined by the

115   Declaration of Helsinki.

116   Research participants were recruited using posters distributed throughout the Memorial

117   University of Newfoundland campus athletic facilities and Physical Education Building, as well

118   as local running retail outlets in the community of St. John's, NL, Canada. A standard

119   recruitment email was also distributed to local running clubs and the Memorial University of

120   Newfoundland's varsity running team.

121   **Participants**

122   Inclusion criteria consisted of the following: i) male participants; ii) aged between 19 and

123   30 years; iii) experienced runners, operationally defined as a function of running experience (≥ 2

124   years of active running training), frequency (≥ 4 days of running per week), and duration (≥ 30

125   minutes per day spent running); iv) competitive racing experience (≤ 18 minutes to complete 5

126   km; ≤ 40 minutes to complete 10 km); v) experience training at a high intensity (≤ 4 min km^{-1}

127   running pace, ≥ 1 day per week); vi) free of any chronic illnesses including cardiometabolic,

128   neurological, or psychiatric diagnoses, or neuromuscular and musculoskeletal injuries, for at

129   least 3 months; vii) active use of a minimalist running shoe (≤ 4mm heel-toe drop, measured as

130   the difference between the sole height of the heel and toe of the shoe), with greater than 3

131   months of experience and at least 3 days of use per week, for at least 30 minutes per session; and

132   viii) naïve to BF running.

133   Twenty-three participants responded to recruitment materials. Of these participants, nine

134   were eligible to participate. One participant withdrew from the study after initial enrollment, due

135   to personal time constraints. Thus, eight adult male distance runners were enrolled in the present

136   study. No *a priori* power calculations were performed to arrive at this sample size; rather, this

137   convenience-sample of eight participants was examined as an exploratory study, to generate data

138   intended to inform further research on the present topic. To limit variability in SRT results, we

139   recruited male participants only, given well-documented sex differences in SRT performance

140   throughout the literature (Jain, Bansal, Kumar, & Singh, 2015; Karia, Ghuntla, Mehta, Gokhale,

141   & Shah, 2012; Silverman, 2006; Woods, Wyma, Yund, Herron, & Reed, 2015). Participants

142   were all competitive runners in the general preparatory phase of their training. Participants were

143   experienced with treadmill running. Participants completed both a short- and long-form Physical

144   Activity Readiness Questionnaire (PAR-Q) (Canadian Society for Exercise Physiology (CSEP),

145   2002) to ensure that they were injury-free for at least 3 months prior to enrolling in the study,

146   and to screen for any injuries or health conditions that would preclude their inclusion in the

147   study. Participants were instructed to refrain from strenuous exercise at least 36 hours prior to

148   testing (Dannecker & Koltyn, 2014); to avoid caffeine, alcohol, drugs, or supplements at least 24

149   hours prior to testing; and were required to obtain at least 6 hours of sleep the night prior to each

150   testing session.

151   **Experimental Conditions**

152   Each participant was subjected to both BF and SH experimental conditions in a crossover

153   fashion (Figure 1). For the BF running condition, rubber-gripped toe-socks (Gaiam No Slip Yoga

154   Socks, Gaiam Inc., Boulder, CO, USA) were used. All participants were naïve to BF running and

155   running in the socks provided. As participants had likely not developed the appropriate responses

156   to minimize discomforts associated with true barefoot running (Lieberman, 2012; Robbins et al.,

157   1993), the toe-socks were used to help minimize potential abrasions or friction burns associated

158   with true barefoot running on a treadmill (Snow et al., 2016). Previous studies have employed

159   similar garments during assessments of BF running (Divert, et al., 2008; Snow et al., 2016). For

160   the SH running condition, participants were required to bring in a pair of their own running shoes

161   (Snow et al., 2016), to mitigate any negative influences footwear discomfort may have on SRT

162   (Mündermann, Nigg, Humble, & Stefanyshyn, 2003). In accordance with previous studies, these

163   running shoes were > 225 g in mass, had a > 5 mm heel-toe drop, and were with or without

164   medial arch support or impact attenuation features (Esculier, Dubois, Dionne, Leblond, & Roy,

165   2015; Rixe, Gallo, & Silvis, 2012). Participants did not wear minimalist footwear during the

166   experiment.

167   **Experimental Set-up and Protocol**

168   The experimental protocol was administered over two testing sessions separated by ≥ 48

169   hours, as depicted in Figure 1. All testing sessions were conducted in the morning.

170   **Testing session one.** During this baseline session, participants' informed consent,

171   anthropometrics (i.e., body mass, height), and demographic information were collected first

172   (Table 1, Table 2). Participants were then familiarized with the experimental conditions and set-

173   up, before completing an incremental treadmill exercise test. All running trials were conducted

174   on a Cybex 750T motorized treadmill (Cybex International, Inc., Medway, MA, USA) set at a

175   constant 1% grade to account for air-resistance experienced when running outdoors (Jones &

176   Doust, 1996).

177   For familiarization, participants were instructed to run at a self-selected treadmill speed

178   in both their standard running footwear (SH running, 11.0 ± 0.5 km h^{-1}) and the toe-socks

179   provided (BF running, 10.7 ± 0.8 km h^{-1}), for 2.5 minutes each, in random order. Heart rate (HR)

180   was not assessed during these running trials. Furthermore, these running trials were not intended

181   to habituate participants to the footwear conditions in advance of SRT testing, but to provide

182   them with an expectation of how each running condition felt, to aid in their decision to either

183   continue in the subsequent study session or withdraw. Immediately following this familiarization

184   session, exercise testing was conducted, and consisted of an incremental treadmill test to

185   exhaustion. The treadmill test was used to determine maximal O_2 uptake (VO_{2max}) and maximal

186   aerobic speed (MAS), defined as the participants' running speed at VO_{2max} (Basset, Chouinard,

187   & Boulay, 2003). Participants were instructed to wear their preferred footwear for exercise

188   testing, given prior evidence that running economy is greater when participants wear shoes with

189   a higher comfort rating (Luo, Stergiou, Worobets, Nigg, & Stefanyshyn, 2009). The incremental

190   test started at a treadmill speed of 7.0 km h^{-1} and was increased by 1.0 km h^{-1} every 2 minutes

191   until participants reached volitional exhaustion (Leger & Boucher, 1980). To ensure participants

192   reached VO_{2max} upon volitional exhaustion (as opposed to peak VO_2), they recovered for 5

193   minutes at walking speed prior to the treadmill speed being increased to 105 % of MAS

194   (Rossiter, Kowalchuk, & Whipp, 2006). Participants were instructed to maintain 105 % of MAS

195   until they reached their limit of tolerance (Rossiter et al., 2006). All participants reached VO_{2max}

196   during the treadmill test.

197   Exercise metabolic rate of the incremental test was recorded with an indirect calorimetry

198   system (AEI Technologies, Inc., Pittsburgh, PA, USA). Oxygen uptake (VO_2), carbon dioxide

199   (VCO_2), breathing frequency (Bf), and tidal volume (V_T) were continuously collected with an

200   automated open-circuit gas analysis system using O_2 and CO_2 analyzers (Model S-3A and Anarad

201   AR-400, Ametek, Pittsburgh, PA), and a pneumo-tachometer (Model S-430,

202   Vacumetrics/Vacumed Ltd., Ventura, CA) with a 4.2 L mixing chamber. Respiratory exchange

203   ratio (RER) and minute ventilation (V_E) were calculated as the quotient of VCO_2 on VO_2 and as

204   the product of Bf by V_T, respectively. Online HR data were wirelessly transmitted to the AEI

205   indirect calorimetric system with a telemetric Polar HR monitor (Polar Electro, Oy, Finland).

206   Prior to testing, volume and gas analyzers were calibrated with a 3.0 L calibration syringe and

207   medically certified O_2 and CO_2 calibration gases that were 16% O_2 and 4% CO_2, respectfully. The

208   data were online digitalized from an A/D card to a computer for monitoring the metabolic rate

209   (AEI Metabolic System Software, AEI Technologies, Inc., Pittsburgh, PA, USA). Results of the

210   VO_{2max} testing were used to determine running speeds implemented during later experimental

211   trials.

212   **Testing session two.** On day two of testing participants completed two, 10-minute

213   running trials, one BF and the other SH. During each of the 10-minute trials participants' SRT

214   was tested 10 times every minute. Participants' HR was not measured during these running trials.

215   Both BF and SH running conditions were completed at 70% of the participants' MAS, which

216   was believed to coincide with a level of physiological arousal that optimizes SRT (Brisswalter et

217   al., 2002; Collardeau et al., 2001). Past work suggests that exercise at such an intensity and

218   duration can facilitate cognitive processes during exercise (Lambourne & Tomporowski, 2010;

219   Tomporowski, 2003). This exercise intensity was selected to emphasize the potential effect that

220   footwear condition would have on SRT, without the contaminating effect of fatigue or

221   inappropriate exercise intensity. Conditions were pseudo-randomized and counterbalanced

222   across the study sample, such that the order of BF and SH running was reversed for every other

223   participant, to prevent an order effect of running conditions on SRT performance.

224   SRT was defined as the time required to press a hand-held button in response to the flash

225   of a 40 W soft-white light bulb placed in the center of the participants' visual field. The SRT

226   device used presently was developed at the Memorial University of Newfoundland and has been

227   used in previous research examining exercise effects on SRT (Behm, Bambury, Cahill, & Power,

228   2004). The between- and within-session reliability of SRT measurements was shown by intra-

229   class correlation coefficients of 0.60 and 0.79 (moderate to good reliability), respectively, with

230   no statistically significant ($p > 0.05$) differences between test and re-test values (Behm et al.,

231   2004). Participants held the button apparatus in their dominant hand during all SRT procedures.

232   The apparatus was also affixed to participants' dominant wrist with a fabric-lined Velcro strap,

233   to prevent dropping. To eliminate any auditory distractions, participants wore ear-plugs along

234   with a noise-cancelling headset. To eliminate any visual distractions, barricades restricted

235   participant's peripheral field of view. Both triggering of the light bulb (SRT stimulus) and the

236   button-press (SRT response) were recorded at 2000 Hz, sampled using a BIOPAC MP100

237   biological amplifier, and displayed using AcqKnowledge 3.9.1 software (BIOPAC Systems, Inc.,

238   Goleta, CA, USA). All SRT data were stored offline on a computer and later pre-processed using

239   AcqKnowledge and Microsoft Excel software.

240   Prior to commencing each running condition, participants completed three, 20-stimulus,

241   SRT familiarization trials while standing on the treadmill at rest (Brisswalter et al., 1997, 1995).

242   Prior to both SRT familiarization and exercise periods, participants were instructed to focus on a

243   small target just below the light bulb and to respond quickly and vigilantly to the presented

244   stimuli. Following SRT familiarization, participants warmed up for 5 minutes at their self-

245   selected treadmill speed (SH running, 11.0 ± 0.5 km h^{-1}; BF running, 10.7 ± 0.8 km h^{-1}),

246   completed the required condition (i.e. BF or SH), and then rested for 3 minutes prior to repeating

247   the protocol, completing the second condition. In combination with the subsequent

248   familiarization SRT trials, participants were inactive (i.e., not running) for a total of 6 minutes.

249   This time allowed for recovery of HR between running conditions (Saltin et al., 1968), with the

250   intention of not influencing cognitive performance under the subsequent condition (Lambourne

251   & Tomporowski, 2010). During each 10-minute condition (i.e., BF and SH), SRT testing was

252   administered in blocks of 10 SRT stimuli, delivered over the last 50 seconds of each minute, with

253   each of the stimuli separated by a random interval to prevent anticipation of subsequent trials

254   (Schmidt & Lee, 2005). The above setup was intended to produce a dual-task effect, to examine

255   which running condition would have a greater influence on participants' SRT. To complement

256   the objective SRT information provided we also asked participants to briefly comment on their

257   experience of BF versus SH running.

258   Video footage was gathered on the right lower-limb, for both SH and BF running

259   conditions to assess stride frequency. A Sony HDR-CX430VB 30 Hz video camera (Sony

260   Computer Entertainment America, San Mateo, CA, USA) was positioned perpendicular to the

261   treadmill at a distance of 1.5 metres and a height of 0.75 metres. Video footage was collected at a

262   30 Hz frame rate, in accordance with previous literature (Macpherson, Taylor, McBain, Weston,

263   & Spears, 2016; Nikodelis, Moscha, Metaxiotis, & Kollias, 2011), with a total of 30 running

264   strides per participant being collected for each running condition (i.e., BF and SH). Raw video

265   data were converted to MPEG-4 using Sony PMB software (Sony Computer Entertainment

266   America, San Mateo, CA, USA) for further analysis.

267   **Data Analyses**

268   **VO_{2max}.** Participants' VO_{2max} was considered the peak value in O_2 uptake using a 30-

269   second moving window average technique. MAS was the corresponding treadmill speed at

270   VO_{2max} (American College of Sports Medicine (ACSM), 2013). HR_{max} was defined as the peak

271   HR value obtained during the VO_{2max} test (ACSM, 2013).

272   **Stride frequency.** The Kinovea (Version 2.0) high-resolution video analysis software

273   platform (http://www.kinovea.org/) was used to determine the frame of foot-contact and toe-off

274   during each 10-second window, for each minute, throughout each 10-minute trial, for both the

275 BF and SH running conditions (Damsted, Nielsen, & Larsen, 2015; Padulo et al., 2015). To

276 minimize error in video interpretation, blind cross-checks were performed by two researchers

277 (NJS, JMB). Foot-contact and toe-off were used to determine stride frequency (strides s^{-1}) by

278 counting the number of complete strides per 10 seconds of video data. This number was then

279 multiplied by 6 to provide the final stride frequency estimate (strides min^{-1}).

280   **SRT.** Participants' SRT was considered the time difference (in seconds) between the

281 initiation of the SRT stimulus (light bulb) and the completion of the SRT response (button press)

282 (Magill, 2011). As such, SRT encompassed participants' overall response time, which is

283 comprised of both reaction time (i.e., time between stimulus presentation and initiation of

284 response) and movement time (i.e., time between response initiation and response completion)

285 (Magill, 2011). Therefore, our SRT measure contained a global measure of both stimulus

286 detection (reaction time) and response execution (movement time) but did not distinguish

287 between them. Any SRT trial < 0.160 seconds was considered an anticipated response and was to

288 be omitted from the data set (Brisswalter et al., 1997, 1995; Collardeau et al., 2001). However,

289 zero SRT responses met this criterion, and thus no SRT trials were omitted from the data set on

290 this basis. We also analyzed SRT errors, which consisted of instances where participants did not

291 respond to the stimulus (light bulb), or when SRT trials > 1.0 seconds were recorded (Woods et

292 al., 2015). No SRT trials exceeded 1.0 seconds, and so SRT errors were considered only those

293 trials that were un-recorded. The number of un-recorded SRT responses were counted by the

294 AcqKnowledge software during each minute and averaged across each total running trial (BF,

295 SH). Remaining SRT trials were averaged over each minute for their respective running

296 conditions (i.e., BF and SH running). Increasing SRT (in seconds) was indicative of an increase

297 in perceptual latency and attentional load.

298 **Statistical Analyses**

299   All data were examined for normality using the Shapiro-Wilk test and visual examination

300 of histogram plots. Because of sensitivity to sample size variations in statistics-based normality

301 tests, as well as the robustness of within-subjects designs to normality violations, we used a

302 stringent significance level of $p < 0.001$ in objective examinations of the data distributions (i.e.,

303 Shapiro-Wilk test) (Gamst, Meyers, & Guarino, 2008; Mang, Snow, Wadden, Campbell, &

304 Boyd, 2016).

305   The effect of BF versus SH running on SRT was tested using a two-way (2 levels × 10

306 levels) repeated-measures analysis of variance (rmANOVA) with the factors Condition (BF

307 running, SH running) and Time (1-10 min). To determine if SRT during BF running, SH

308 running, or running in general was different from rest, the average SRT from the familiarization

309 trials, the BF and SH running conditions, and both exercise conditions combined was compared

310 using a one-way (4 levels) rmANOVA with the factor Condition (Familiarization, BF running,

311 SH running, Combined running). *Post hoc* pairwise comparisons were conducted when

312 necessary using the Bonferroni correction. Mean SRT errors (number of trials) were compared

313 across BF and SH running conditions using a paired samples *t*-test. Finally, average stride

314 frequency (strides min^{-1}) was compared across conditions (BF running, SH running) using a

315 paired samples *t*-test.

316   All results are presented as means ± one standard deviation (SD). Statistical significance

317 was set at $p < 0.05$. Effect sizes (Cohen's *d*) and 95% confidence intervals (95%CI) of effect

318 sizes were calculated for our primary outcome (SRT in seconds) using Microsoft Excel, and

319 interpreted as "trivial" < 0.20; "small" 0.20-0.49; "medium" 0.50-0.79; "large" > 0.80 (Cohen,

320   1988). All statistical analyses were conducted in SPSS (Version 20, IBM Corporation, Armonk,

321   NY, USA).

Results

Data Inspection

324   All data were deemed normally distributed based on Shapiro-Wilk statistics (SRT $W_{(8)}$ =

325   0.774–0.990, p = 0.015–0.996; stride frequency $W_{(8)}$ = 0.876–0.912, p = 0.171–0.368) and

326   histogram plot inspection. For SRT data, Mauchly's Test of Sphericity was not statistically

327   significant ($p > 0.05$); thus, sphericity was assumed for interpreting the results of the rmANOVA

328   on SRT values.

Participants

330   **Baseline characteristics.** Participants were on average 25.1 ± 3.7 years of age, with a

331   body mass, height, and body mass index (BMI) of 78.4 ± 8.9 kg, 180.7 ± 7.8 cm, and 24.0 ± 2.0

332   kg m^{-2}, respectively (Table 1). Their training experience ranged from 1 to 8 years (3.1 ± 2.1 yr),

333   and all participants were experienced in using minimalist footwear (11.5 ± 11.4 mo). Participants

334   completed an average of 8.1 ± 3.5 training sessions per week, including 1.9 ± 0.8 sessions of

335   interval training at > 75% VO_{2max}. Total training volume was 90.0 ± 44.7 km per week, and 65.3

336   ± 44.9% of training volume was completed using minimalist footwear (72.3 ± 62.0 km wk^{-1}).

337   Average 10 km personal best race time (mm:ss) was 37:26 ± 2:50. This information is detailed in

338   Table 2.

339   **$V\dot{O}_{2max}$ testing.** Baseline exercise testing results can be found in Table 1. Participants'

340   VO_{2max} was on average 61.4 ± 6.7 mL min^{-1} kg^{-1}, corresponding to "excellent" fitness (ACSM,

341   2013). In fact, all participants achieved VO_{2max} scores in the 95th to 99th percentile based on age

342   and sex norms (ACSM, 2013). Average HR_{max} was 191 ± 4 bpm (96.5 ± 6.5% age-predicted

343 HR_{max}). Mean maximal aerobic speed (MAS) was 17.9 ± 1.3 km h^{-1}, while 70% MAS (for BF

344 and SH running SRT trials) was 12.5 ± 0.9 km h^{-1}.

345 **SRT**

346 SRT results from BF running, SH running, and combined across conditions are shown in

347 Figure 2. A statistically significant main effect of Time ($F_{(9, 63)} = 3.097$, $p = 0.004$) was present

348 when assessing SRT. Statistically significant increases in SRT were present at 7 minutes relative

349 to 5 minutes (0.29 ± 0.02 s vs. 0.27 ± 0.02 s, $p < 0.05$, $d = -0.99$, 95%CI = -1.98 to +0.09, large

350 effect), and at 9 minutes relative to 2 minutes (0.29 ± 0.03 s vs. 0.27 ± 0.03 s, $p < 0.05$, $d = -0.67$,

351 95%CI = -1.63 to +0.37, moderate effect). There was neither a statistically significant main

352 effect of Condition ($F_{(1, 7)} = 1.002$, $p = 0.350$) nor a statistically significant Condition × Time

353 interaction effect ($F_{(9, 63)} = 1.233$, $p = 0.292$). Examination of effect sizes between conditions

354 indicated that overall, BF running had a small negative effect on SRT ($d = -0.32$, 95%CI = -3.29

355 to +2.65). The largest negative effect BF running had on SRT was at 8 minutes ($d = -0.80$,

356 95%CI = -1.65 to +0.06, large effect; BF SRT = 0.30 ± 0.03 s, SH SRT = 0.27 ± 0.03 s) when

357 compared to SH running. However, this effect was not statistically significant ($p > 0.05$).

358 Figure 3 illustrates average SRT values for the familiarization trials and each

359 experimental condition, with an increase in SRT indicating a decrement in SRT performance.

360 When comparing the average SRT for the familiarization trial (0.25 ± 0.03 s), SH running (0.27

361 ± 0.02), BF running (0.28 ± 0.03 s), and combined trials across both conditions (0.28 ± 0.02 s),

362 there was no statistically significant main effect of Condition ($F_{(3, 21)} = 2.944$, $p = 0.057$).

363 Figure 4 demonstrates SRT errors during BF and SH running trials. There were no SRT

364 errors during familiarization periods. SRT errors represented 17.6% and 17.0% of total SRT

365 trials under the BF and SH running conditions, respectively (17.6 ± 6.6 trials vs. 17.0 ± 13.0

366 trials). There was no statistically significant difference in SRT errors across conditions ($t_{(7)}$ =

367 1.07, $p = 0.918$).

368   Finally, seven participants reported feeling an increase in attentional demands during BF

369 relative to SH running, while one participant noted no difference. In general, seven of eight

370 participants (88%) highlighted: i) a need to focus more on their footfalls to prevent

371 uncomfortable landings; ii) a perceived change in foot-strike patterns; and iii) pain or burning on

372 the plantar surface of the foot.

373 **Stride Frequency**

374   Stride frequency showed a statistically significant increase during BF running (88.3 ± 5.6

375 strides min^{-1}), relative to SH running (86.1 ± 5.7 strides min^{-1}, $p < 0.05$, $d = 0.39$, 95%CI = -0.62

376 to +1.36, small effect).

377   **Discussion**

378   The primary aim of the present study was to determine whether there was a difference in

379 SRT during acute bouts of BF and SH running, in competitive distance runners naïve to BF

380 running. Despite a statistically significant increase in SRT during later time-points of the

381 exercise bouts compared to earlier, we did not observe a statistically significant difference in

382 SRT across footwear conditions. We also did not find a statistically significant difference in SRT

383 errors between conditions. However, there was a statistically significant increase in stride

384 frequency during BF running; and participants anecdotally reported having perceived an increase

385 in attentional demands during BF relative to SH running.

386 **SRT and Attentional Demands**

387   Reaction time is an ecologically-relevant measure of perceptual-motor cost of running

388 (Schmidt & Lee, 2005), due to the high prevalence of acute injuries sustained during running

389   (Hsu, 2012; Knobloch et al., 2008), combined with the common nature of situations requiring

390   reactions to extrinsic stimuli (Magill, 2011). In some instances, individuals must react quickly

391   and suddenly to an unexpected stimulus to avoid injury, making it imperative to avoid any threat

392   to reaction time performance (Magill, 2011; Schmidt & Lee, 2005). On this basis, increased SRT

393   has been linked to a possible increased injury risk during running, due to falls and sprains

394   (Beynnon et al., 2001; Konradsen & Ravn, 1990, 1991; Murphy & Connolly, 2003; Richardson

395   et al., 2017; Willems et al., 2005). Past work highlights that runners need to pay more attention

396   to their foot-strikes during BF running (Alloway et al., 2016), and to alter their running

397   kinematics to avoid noxious plantar stimuli (Lieberman et al., 2010). Consequently, we

398   hypothesized that BF running would produce a detrimental effect on SRT performance, with

399   reference to SH running; yet we observed no statistically significant effect of BF running on SRT

400   or SRT errors.

401   In the present study, participants anecdotally reported an increase in attentional demands

402   during BF relative to SH running, noting: i) a need to focus more on their footfalls to prevent

403   uncomfortable landings; ii) a perceived change in foot-strike patterns, particularly during the

404   latter minutes of BF running; and iii) pain or burning on the plantar surface of the foot. A recent

405   study directly comparing BF and SH running trials on an indoor track showed that runners had to

406   pay greater attention to their foot-strikes during the BF condition, as evidenced by greater

407   working memory when stepping on targets during running (Alloway et al., 2016). This

408   observation is supported by work that has indicated that SRT performance is decreased in the

409   presence of externally applied cutaneous stimulation (Hanson et al., 2009). When considering the

410   concept of dual-task interference, which emphasizes participants' limited attentional capacity

411   (Watanabe & Funahashi, 2017), it could be expected that cognitive task performance would

412 suffer in the presence of an attentionally demanding procedure such as BF running. Therefore, at

413 the same relative intensity, it is possible BF running does not have any additional attentional

414 demand compared to SH running. It is also plausible that by providing participants with rubber-

415 gripped toe socks for the BF running condition, plantar sensory feedback was masked relative to

416 a true BF running condition, introducing a potential confound to our experiment. However, given

417 runners' subjective comments, we consider this possibility unlikely.

418 **Stride Frequency**

419   The statistically significant increase in stride frequency with BF running may reflect

420 kinematic differences between BF and SH running (Divert et al., 2005; Ekizos, Santuz, &

421 Arampatzis, 2017). Increased stride frequency could be the result of increased somatosensory

422 feedback present during BF running and intended to avoid painful foot-strikes (Hsu, 2012;

423 Lieberman, 2012). Indeed, increased sensory feedback during BF running can alter foot-strike

424 patterns, for instance by modulating ankle coordination prior to foot-strike (Kurz & Stergiou,

425 2004), reducing ground reaction forces (Lieberman et al., 2010), and increasing and decreasing

426 stride frequency and contact time, respectively (Ekizos et al., 2017; Kurz & Stergiou, 2004).

427 During SH running, this protective feedback is believed to be impaired (Robbins et al., 1995).

428 We anticipated that such differences in somatosensory feedback would have a limiting effect on

429 attentional capacity, reflected by an increase in SRT. Yet, despite the statistically significant

430 increase in stride frequency during BF running, SRT did not change.

431 **Possible Explanations**

432   Despite anecdotal reports and past research suggesting a potential attentional difference

433 between BF and SH footwear conditions, we did not observe such an effect. There is evidence in

434 support of our finding, that SRT was not different during BF versus SH running. For example,

435   Klint et al. (2008) showed that proprioceptive and cutaneous feedback from the foot and leg can

436   modulate stepping patterns and increase variation in kinematics during BF locomotion,

437   independent of higher processing. They concluded that higher centers are likely reserved for

438   more complex movements. Others have intimated that gait involves the integration of spinal

439   activity, afferent sensory information, and efferent motor commands from the primary motor

440   cortex and pyramidal tract, with reactions to external perturbations being integrated at the

441   cortical or at the spinal level, depending on the nature of the perturbation (Nielsen, 2003).

442   Nielsen (2003) proposes that concomitant spinal and supraspinal regulation of gait allows for

443   more flexible integration of sensory (e.g., visual, somatosensory) and motor information online.

444   This is likely why neural interactions governing gait modulation are rapid, allowing stride-to-

445   stride variation in stepping patterns (Klint et al., 2008; Nigg & Wakeling, 2001).

446   Greater variation of stride kinematics during BF running might therefore be associated

447   with injury prevention and pain reduction, due to a reduction in repeated impact (Lieberman et

448   al., 2010). However, if the increased afferent feedback experienced during BF running does not

449   undergo higher processing (Klint et al., 2008), then runners would be at not greater risk of acute

450   injuries due to stumbles or falls (Beynnon et al., 2001; Konradsen & Ravn, 1990, 1991; D. F.

451   Murphy & Connolly, 2003; Richardson et al., 2017; Willems et al., 2005). This is supported by

452   our finding that BF running did not have a statistically significant effect on SRT. Although

453   speculative in nature, this lack of conscious processing of somatosensory and proprioceptive

454   information would serve a protective role for persons engaging in BF running.

455   **Methodological Considerations and Future Directions**

456   There are a few noteworthy methodological considerations in the current work which

457   could have influenced our findings. Throughout the course of prolonged exercise fatigue can

458   negatively influence corticospinal and neuromuscular output (Meardon, Hamill, & Derrick,

459   2011; Ross, Middleton, Shave, George, & Nowicky, 2007), and consequently reduce perceptual-

460   motor performance (Brisswalter et al., 2002). The present results support existing evidence in

461   that SRT performance tended to increase towards the end of the exercise bout, a result that has

462   been previously reported in the literature (Brisswalter et al., 1995; Brisswalter et al., 2002;

463   Collardeau et al., 2001; McMorris & Keen, 1994). However, this was a short and moderately-

464   intense bout of steady-state exercise (ACSM, 2013), with an appropriately-timed rest period

465   (Saltin et al., 1968); so, fatigue was not likely a major contributor to decreased performance

466   (Lambourne & Tomporowski, 2010; Tomporowski, 2003). Indeed, the exercise duration and

467   intensity were chosen to coincide with a level of physiological arousal that optimizes SRT

468   (Brisswalter et al., 2002; Collardeau et al., 2001; Lambourne & Tomporowski, 2010;

469   Tomporowski, 2003). However, given we did not measure HR or perceived exertion throughout

470   SRT testing, it is possible that participants' level of exertion during exercise was greater than the

471   exercise intensity prescribed. Further work should examine HR and perceived exertion during

472   exercise and SRT testing. Aside from exercise intensity, the decrease in performance observed

473   may have been a result of the mode of exercise (i.e., treadmill exercise), as compared to exercise

474   intensity or fatigue (Lambourne & Tomporowski, 2010). In other words, given the dual-task

475   nature of the present experiment, SRT performance may simply have suffered in response to

476   participants' avoiding falling off the treadmill. Nevertheless, there was no statistically significant

477   difference in SRT during resting familiarization trials compared to exercise. In addition, without

478   the use of treadmill running, it would not have been possible for us to employ the present SRT

479   task.

480   Secondly, our measure of SRT was unable to decompose participants' overall response

481   time, into its constituent components of reaction time (i.e., time between stimulus presentation

482   and initiation of response), which measures stimulus detection; and movement time (i.e., time

483   between response initiation and response completion), which measures response execution

484   (Magill, 2011). Past work has shown that acute exercise preferentially influences movement time

485   over reaction time in SRT tasks (Beyer, Sage, Staines, Middleton, & McIlroy, 2017; Davranche,

486   Burle, Audiffren, & Hasbroucq, 2005, 2006), indicating that exercise-induced changes in

487   response time are related more to faster movement execution than changes in cognitive function

488   (Beyer et al., 2017). Thus, to elucidate the cognitive influence of BF running it would be prudent

489   for further work to examine a greater number of dimensions of task performance, including

490   separating reaction and movement times. Similarly, examining more complex cognitive tasks

491   (e.g., discrimination RT) may better discern the cognitive impacts of BF running, as opposed to

492   SRT which simply examines speed of information processing (Alloway et al., 2016; Beyer et al.,

493   2017). Finally, it is conceivable that the small sample size in this exploratory study may have

494   threatened the validity of the observed results. Likewise, by including a sample of male runners

495   exclusively, our findings may not be generalizable to female athletes. Consequently, future work

496   will benefit from examining a larger sample of runners, including both females and males, and

497   recreational runners who have no experience using minimalist footwear. Subsequent

498   investigations should also sample a larger number of SRT trials over a longer time-period, with

499   measurements of physiological and perceived exertion.

Conclusions

501   In the present exploratory study, an acute bout of BF versus SH running did not impact

502   SRT. It is possible that increased afferent feedback during BF running (Kurz & Stergiou, 2004;

503   Robbins et al., 1993) is responded to in subcortical regions or transcortical reflex pathways

504   (Nielsen, 2003), without affecting the attentional requirements of the task. Additionally, this may

505   be the case only for simple tasks such as SRT. Alternatively, it is possible that our small sample

506   size did not have sufficient power to reveal a significance across BF and SH running conditions.

507   Nevertheless, the present results suggest that although differences in running kinematics across

508   BF and SH running may lead to differences in musculoskeletal injuries (Daoud et al., 2012;

509   Hreljac, 2005), it is not likely that BF running will impact runners' risk of attention-related acute

510   injuries such as trips or falls (Hsu, 2012; Knobloch, Yoon, & Vogt, 2008). Future work should

511   examine whether more complex perceptual-motor tasks and more sensitive outcomes will be

512   affected by BF versus SH running. Further efforts should also examine whether the present

513   observations will emerge in larger sample of runners. Finally, it is prudent to examine whether

514   changes in SRT will manifest when runners are performing over-ground on a stable running

515   surface, as opposed to during treadmill running.

Acknowledgements

516

517   The current study received no external funding support, and the authors have no conflicts

518   of interest to declare. We wish to sincerely thank Mr. Blaise Dubois for his tremendous support

519   during experimental planning, Dr. Normand Teasdale for his generous assistance in reviewing

520   the original manuscript before its initial submission, and Dr. Thamir Alkanani for his technical

521   contributions.

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733 **Figure 1**. Schematic of experimental protocol for simple reaction time (SRT) testing.

734 Briefly, eight participants attended the laboratory on Day 1 for informed consent, measurement

735 of anthropometrics (i.e., body mass, height), collection of demographic information,

736 experimental setup familiarization, and incremental running exercise test for determination of

737 maximal O_2 uptake ($\dot{V}O_{2max}$) and maximal aerobic speed (MAS). On Day 2, participants

738 completed SRT testing under both barefoot (BF) and shod (SH) running conditions. The order of

739 conditions was randomized and counterbalanced across the sample. After completion of one

740 condition, participants crossed-over into the other (black arrow). Prior to commencing either the

741 BF or SH running SRT trials, participants completed three, 20-stimulus SRT familiarization

742 trials while standing at rest. Both SH and BF running conditions were preceded by a 5-min

743 warm-up at participants' self-selected treadmill speed. Participants completed both BF and SH

744 running conditions for 10 min each at 70% MAS. During these running trials, 10 SRT stimuli

745 were presented every minute. A 3-min seated rest period separated conditions; SRT was not

746 tested during warm-up or rest periods.

747 **Figure 2.** Mean SRT from 1 min to 10 min during barefoot (BF Running, black circles

748 with solid line) and shod (SH Running, gray circles with solid line) running conditions, as well

749 as averaged across exercise conditions (Combined, black squares with dashed line). Increasing

750 SRT (s) indicates diminished SRT performance. A statistically significant main effect of Time

751 ($F_{(9, 63)} = 3.097$, $p = 0.004$) was found when assessing SRT. Statistically significant increases in

752 SRT were present at 7 min relative to 5 min (0.29 ± 0.02 s vs. 0.27 ± 0.02 s, $p < 0.05$, $d = -0.99$,

753 95%CI = -1.98 to +0.09, large effect), and at 9 min relative to 2 min (0.29 ± 0.03 s vs. $0.27 \pm$

754 0.03 s, $p < 0.05$, $d = -0.67$, 95%CI = -1.63 to +0.37, moderate effect). Vertical bars represent one

755   SD. Asterisks (*) denote statistically significant differences ($p < 0.05$) at 7 min vs. 5 min, as well

756   as at 9 min vs. 2 min.

757   **Figure 3.** Average SRT values for familiarization, barefoot running (BF Running), and

758   shod running (SH Running) trials, as well as averaged across exercise conditions (Combined).

759   When the average SRT values across familiarization trials (0.25 ± 0.03 s), SH running ($0.27 \pm$

760   0.02), BF running (0.28 ± 0.03 s), and combined exercise trials (0.28 ± 0.02 s) were compared

761   using a one-way (Condition) rmANOVA, the main effect of Condition was not statistically

762   significant ($F_{(3, 21)} = 2.944$, $p = 0.057$). Increasing SRT (s) indicates diminished SRT

763   performance. Vertical bars represent one SD.

764   **Figure 4.** Average SRT errors across barefoot (BF) and shod (SH) running trials. Absent

765   SRT responses represented 17.6% and 17.0% of total SRT trials under the BF and SH running

766   conditions, respectively (17.6 ± 6.6 trials vs. 17.0 ± 13.0 trials). The difference in SRT errors

767   across conditions was no statistically ($t_{(7)} = 1.07$, $p = 0.918$). Vertical bars represent one SD.

Figure 1

Schematic of experimental protocol for simple reaction time (SRT) testing.

Schematic of experimental protocol for simple reaction time (SRT) testing. Briefly, eight participants attended the laboratory on Day 1 for informed consent, measurement of anthropometrics (i.e., body mass, height), collection of demographic information, experimental setup familiarization, and incremental running exercise test for determination of maximal O_2 uptake (VO_{2max}) and maximal aerobic speed (MAS). On Day 2, participants completed SRT testing under both barefoot (BF) and shod (SH) running conditions. The order of conditions was randomized and counterbalanced across the sample. After completion of one condition, participants crossed-over into the other (black arrow). Prior to commencing either the BF or SH running SRT trials, participants completed three, 20-stimulus SRT familiarization trials while standing at rest. Both SH and BF running conditions were preceded by a 5-min warm-up at participants' self-selected treadmill speed. Participants completed both BF and SH running conditions for 10 min each at 70% MAS. During these running trials, 10 SRT stimuli were presented every minute. A 3-min seated rest period separated conditions; SRT was not tested during warm-up or rest periods.

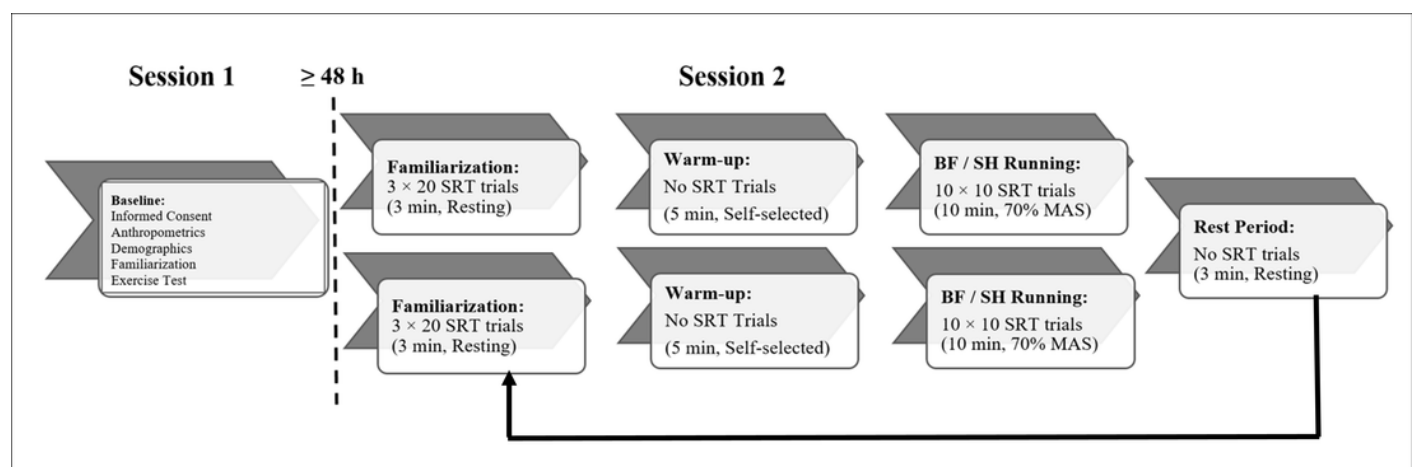



Figure 2

Mean SRT from 1 min to 10 min during barefoot (BF Running, black circles with solid line) and shod (SH Running, gray circles with solid line) running conditions, as well as averaged across exercise conditions (Combined, black squares with dashed line).

Mean SRT from 1 min to 10 min during barefoot (BF Running, black circles with solid line) and shod (SH Running, gray circles with solid line) running conditions, as well as averaged across exercise conditions (Combined, black squares with dashed line). Increasing SRT (s) indicates diminished SRT performance. A statistically significant main effect of Time ($F_{(9, 63)}$ = 3.097, p = 0.004) was found when assessing SRT. Statistically significant increases in SRT were present at 7 min relative to 5 min (0.29 ± 0.02 s vs. 0.27 ± 0.02 s, $p < 0.05$, d = -0.99, 95%CI = -1.98 to +0.09, large effect), and at 9 min relative to 2 min (0.29 ± 0.03 s vs. 0.27 ± 0.03 s, $p < 0.05$, d = -0.67, 95%CI = -1.63 to +0.37, moderate effect). Vertical bars represent one SD. Asterisks (*) denote statistically significant differences ($p < 0.05$) at 7 min vs. 5 min, as well as at 9 min vs. 2 min.

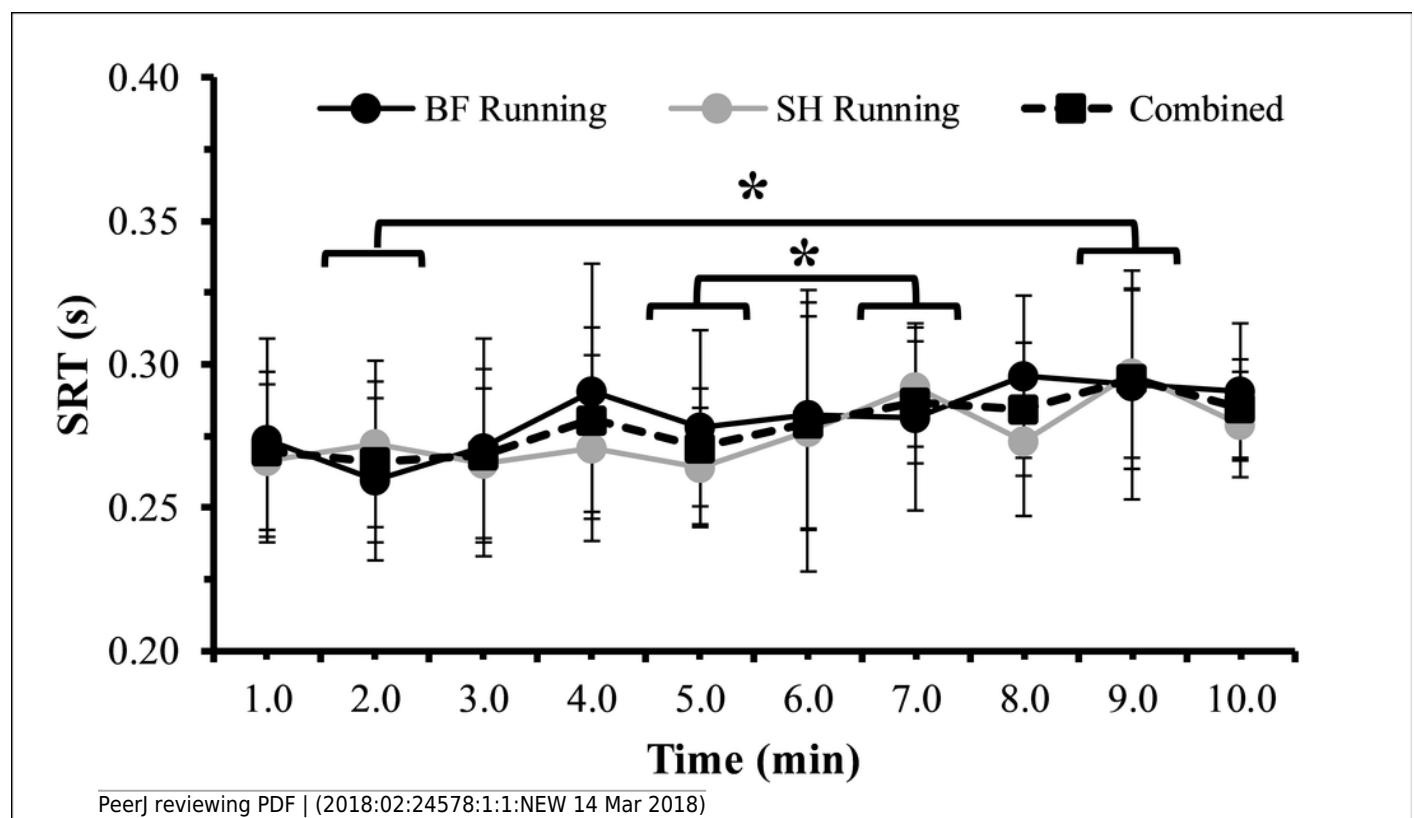



Figure 3

Average SRT values for familiarization, barefoot running (BF Running), and shod running (SH Running) trials, as well as averaged across exercise conditions (Combined).

Average SRT values for familiarization, barefoot running (BF Running), and shod running (SH Running) trials, as well as averaged across exercise conditions (Combined). When the average SRT values across familiarization trials (0.25 ± 0.03 s), SH running (0.27 ± 0.02), BF running (0.28 ± 0.03 s), and combined exercise trials (0.28 ± 0.02 s) were compared using a one-way (Condition) rmANOVA, the main effect of Condition was not statistically significant ($F_{(3, 21)}$ = 2.944, p = 0.057). Increasing SRT (s) indicates diminished SRT performance. Vertical bars represent one SD.

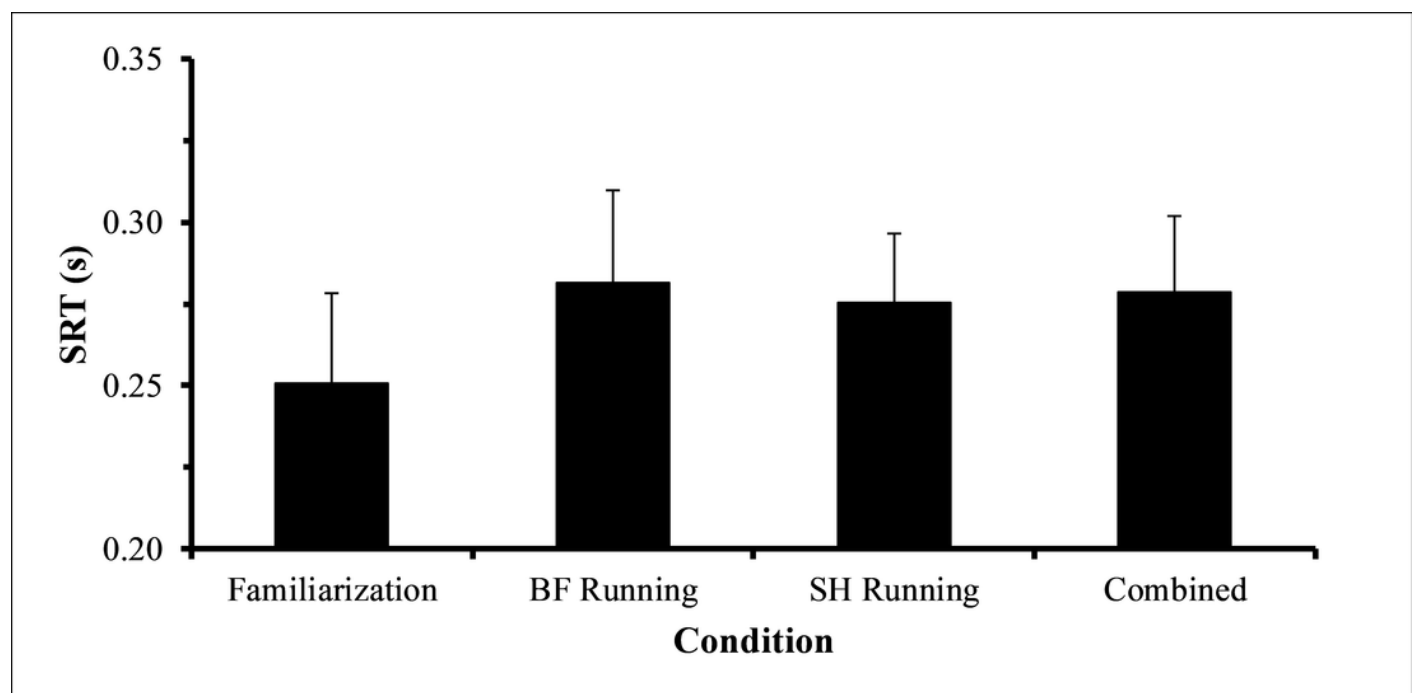
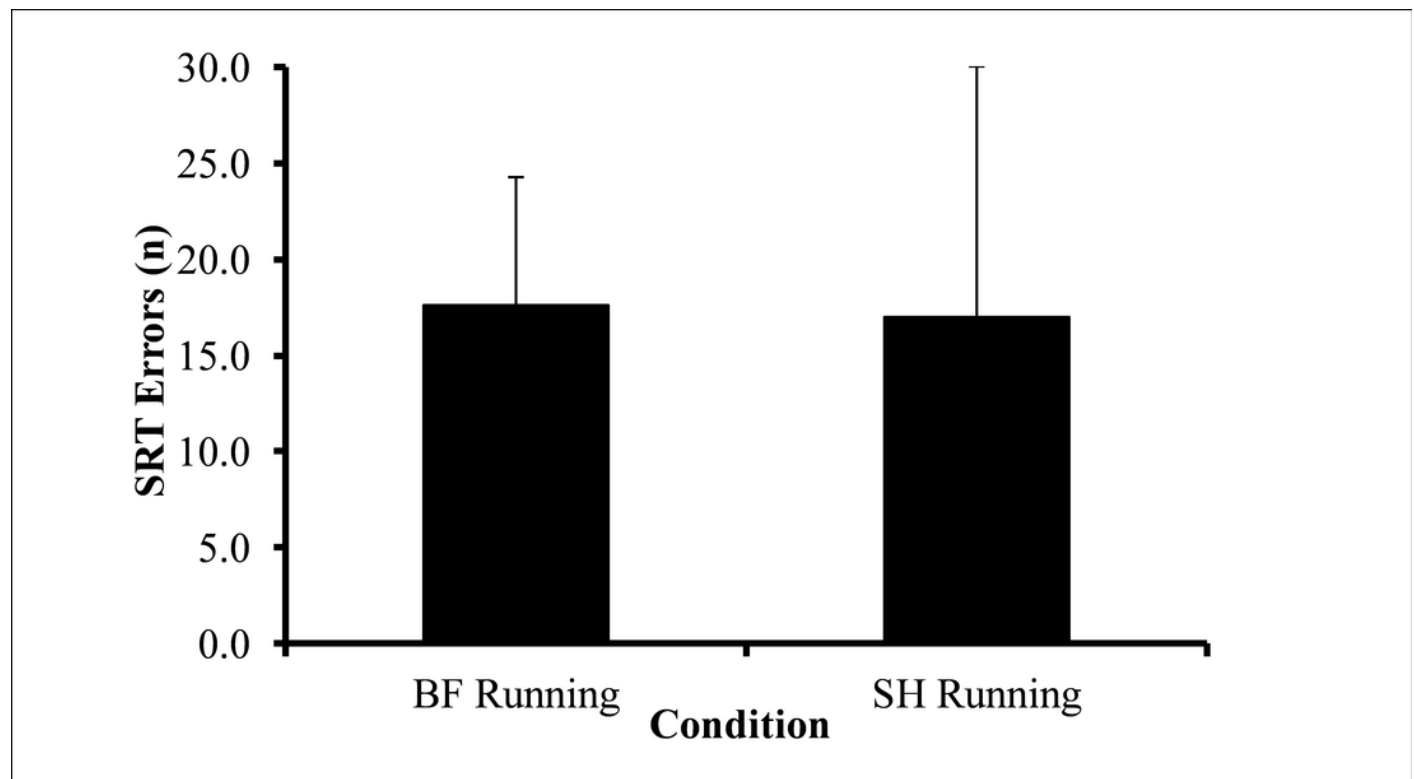



Figure 4

Average SRT errors across barefoot (BF) and shod (SH) running trials.

Average SRT errors across barefoot (BF) and shod (SH) running trials. Absent SRT responses represented 17.6% and 17.0% of total SRT trials under the BF and SH running conditions, respectively (17.6 ± 6.6 trials vs. 17.0 ± 13.0 trials). The difference in SRT errors across conditions was no statistically ($t_{(7)}$ = 1.07, p = 0.918). Vertical bars represent one SD.

Participant characteristics (Mean ± SD).

1   **Table 1.** Participant characteristics (Mean ± SD).

Age	Body Mass	Height	BMI	HR_{max}	% Age-predicted HR_{max}	VO_{2max}	MAS
(yr)	(kg)	(cm)	(kg m^{-2})	(bpm)	(%)	(mL min^{-1} kg^{-1})	(km h^{-1})
25.1 ± 3.7	78.4 ± 8.9	180.7 ± 7.8	24.0 ± 2.0	191 ± 4	96.5 ± 6.5	61.4 ± 6.7	17.9 ± 1.4

2   BMI, body mass index; HR_{max}, maximal heart rate; VO_{2max}, maximal oxygen uptake; MAS, maximal aerobic speed.

Participant training profile (Mean ± SD).

1   **Table 2.** Participant training profile (Mean ± SD).

Training Experience	Training Sessions	Interval Training (> 75% VO_{2max})	Training Load	Minimalist Shoe Experience	Minimalist Training Load	10 km Personal Best
(yr)	(n wk^{-1})	(n wk^{-1})	(km wk^{-1})	(mo)	(km wk^{-1})	(min:s)
3.1 ± 2.1	8.1 ± 3.5	1.9 ± 0.8	90.0 ± 44.7	11.5 ± 11.4	72.3 ± 62.0	37:26 ± 2:50

2   VO_{2max}, maximal oxygen uptake.