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MINIMALIST SHOE TRAINING DOES NOT PROMOTE FOREFOOT RUNNING OR LOADING RATE ATTENUATION IN EXPERIENCED SHOD RUNNERS

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INTRODUCTION

Transitioning to minimalist shoes has become extremely popular amongst experienced shod runners. Proponents of minimalist shoe running advocate that adaptation from a rearfoot strike (RFS) to either a midfoot strike (MFS) or forefoot strike (FFS) is necessary to attenuate external vertical average loading rate (VALR) on the body. One possible implication is that VALR is a kinetic parameter associated with running injuries such as tibial stress fractures [4]. Furthermore, it is commonly assumed that adaptations in footstrike pattern and attenuation of VALR occur with more minimalist shoe experience or training. The limited data that exists on minimalist shoe running has been performed on those unaccustomed to it [1], or on those already experienced in barefoot running [2]. The longitudinal effect of minimalist shoe training in experienced shod populations appears to have been neglected in pervious literature. Although, one study has shown an inclination to adapt from a rearfoot strike (RFS) towards a forefoot strike (FFS) landing pattern after six weeks of minimalist shoe training [3]. Further research is warranted to confirm or refute the hypothesis that short term training in minimalist shoes will attenuate VALR via footstrike pattern alteration. Therefore, the primary purpose of this study was to determine if VALR could be attenuated and footstrike pattern would be adapted as a result of seven-weeks of minimalist shoe training. A secondary objective was to determine the association between footstrike pattern and VALR.

METHODS

Twenty-two healthy male shod endurance runners (age 24 ± 2.2 yrs; weekly mileage 27 ± 5.9 km) were randomly assigned into two groups: an experimental (EXP) group who underwent a seven-week Vibram Fivefingers Bikilas® training program; and control (CONT) group who maintained usual shod training during the study. Lower limb biomechanics were recorded with a Vicon® (eight cameras) motion capture system, synchronized with a Bertec® force plate. Twelve bilateral running trials from all participants were performed for three randomized shoe conditions: barefoot (BF); minimalist shoes (VF); and shod (SH) at pre- and post-tests respectively. Self-selected running speeds were monitored with timing gates at 3.5 m/s ± 10 % (within day) ± 1 % (between day pre-post). Footstrike patterns were determined using strike index according to center of pressure trajectory and classified by a rearfoot strike (RFS) 0 – 33%; midfoot strike (MFS) 34 – 66%; and a forefoot strike (FFS) 67 – 100% [5]. Strike index was confirmed by ankle plantar-dorsiflexion footstrike angles. Three-dimensional kinematic data of the lower limbs were filtered with a low pass, fourth order, zero lag Butterworth digital filter with a cut-off frequency of 12 Hz. Ground reaction force (GRF) was filtered with a recursive forth order low pass Butterworth digital filter with a cut-off frequency of 75 Hz, and normalized to each participant's body weight (kg). Vertical average loading rate (VALR) was determined as the steepest portion (20 – 80%) of the impact transient peak. Force-time profiles of EXP group at post-testing for all three shoe conditions are represented in **Figure 1**. Matlab© was used to process all running trials with clean force plate hits (pre- and post-testing for both EXP and CONT groups).

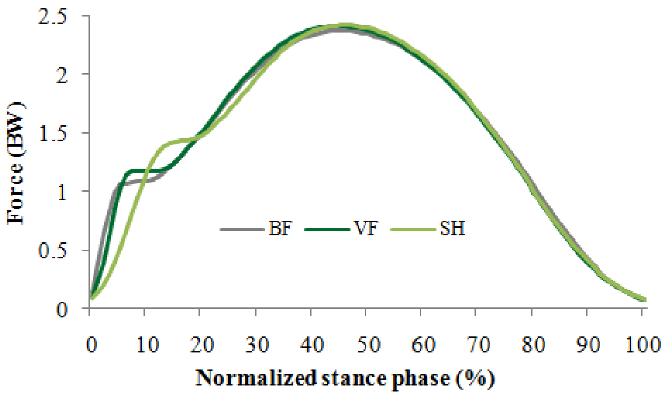


Figure 1: Vertical GRF profile over stance between three footwear conditions: barefoot (BF); minimalist shoes (VF); and shod (SH) for experimental (EXP) group at post-testing.

The VF training intervention consisted of progressive increases in running mileage which started at ~ 11% to 22% of their usual SH training distance on their first VF training session. By the end of the seven-week intervention participants were running ~ 52% - 132% of their usual SH training distance while in the VF. Participants ran a total VF mileage of 77.43 ± 14.39 km at running speeds of 3.46 m/s ± 8 % over the VF intervention, recorded using global positioning system (GPS sports®) units. No instruction was provided on running technique during the intervention. All VF training sessions were monitored personally by the primary investigator. Pearson's correlations were done to determine the relationship between footstrike pattern (using strike index) and VALR for the three shoe conditions respectively. T-tests were used to determine any statistically relevant pre-post changes between EXP and CONT group for relevant parameters of interest (strike index and VALR).

RESULTS AND DISCUSSION

Pearson's correlation coefficients revealed that higher strike index (towards FFS) showed a moderate to good association with a lower VALR in the BF condition ($r = -0.57$; $p = 0.002$) and VF condition ($r = -0.68$; $p = 0.0001$), but was only weekly associated in the SH condition ($r = 0.32$; $p = 0.01$). **Figure 2** shows how VALR was attenuated most when adopting FFS landings in BF and VF running.

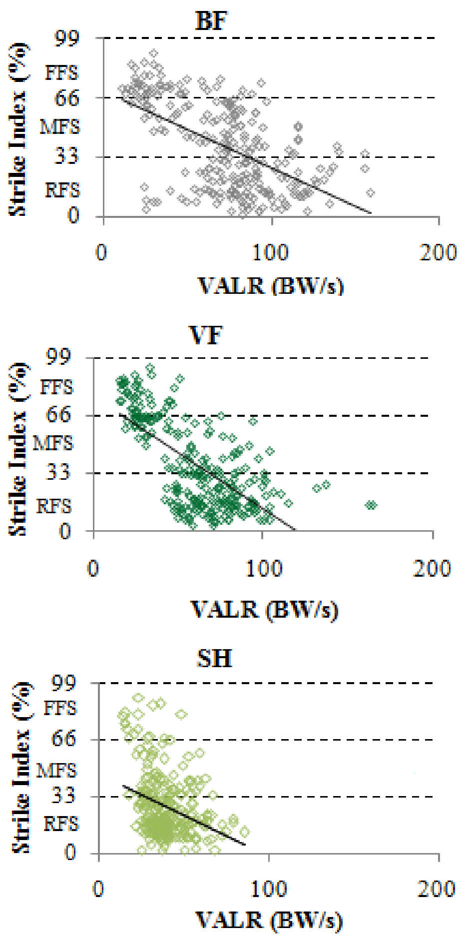
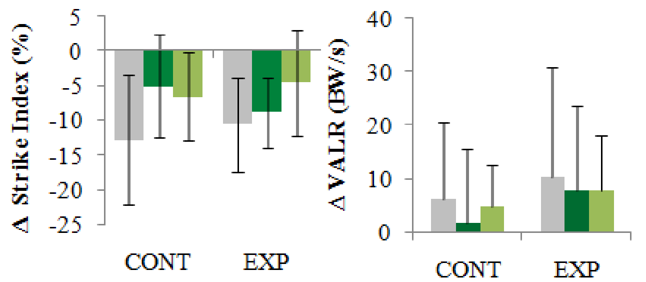


Figure 2: Scatter plots of relationship between vertical average loading rate (VALR; BW/s) and strike index (%) distributed among three shoe conditions: barefoot (BF); minimalist shoe (VF); and shod (SH). Horizontal dotted lines divide footstrike patterns accordingly: forefoot strike (FFS); midfoot strike (MFS); and rearfoot strike (RFS).

No statistically significant learning effect with regards to footstrike pattern adaptation (**Figure 3a**) or VALR attenuation (**Figure 3b**) was observed in the EXP group after seven-weeks of VF training ($p > 0.05$). In contrast to what was hypothesized, the EXP group showed a propensity towards a decrease in strike index (shift from MFS towards RFS) from pre-post for BF running (48.3 ± 22.1% to 38.3 ± 24.6%); VF running (49.6 ± 25.5% to 40.2 ± 24.7%); and SH running (34.4 ± 21.1% to 29.8 ± 21.9%) . This change in footstrike landing may have accounted for the tendency for VALR to increase in the EXP group for BF running (65.6 ± 34.1 BW/s to 75.2 ± 36.9 BW/s); VF running (53.6 ± 28.6 BW/s to 63.3 ± 31.8 BW/s) as well as SH running (36.6 ± 10.3 BW/s to 44.3 ±15.8 BW/s) from pre- to post. Although not statistically significant, the increase pre-post for the EXP group in VARL by ~20% for BF, and ~21% for VF may be considered clinically significant (≥ 15%) for tibial stress fracture development [6].



a) b)

Figure 3: Absolute mean differences (Δ) pre-post for: a) strike index (%); and b) vertical average loading rate (VALR; BW/s) among all conditions for both experimental (EXP) and control (CONT) group.

CONCLUSIONS

These findings challenge the assumption that short term minimalist shoe training may result in natural tendencies to adapt towards a FFS landing. These results may also reject the premise that VALR will be attenuated as a shod runner gains more experience in VF training. This is a confounding, considering that FFS landings were moderately associated with lower VALR for the VF condition. Other kinematic factors could contribute to minimizing VALR. Inability to adapt to VF training could be attributed to insufficient time permitted for kinematic habits to develop such as comparable to that of experienced barefoot runners who use mostly FFS or MFS landings [3]. Future studies are warranted to investigate the VF transition over longer periods of time, or could incorporate coaching of appropriate kinematics or technique if VALR attenuation is a desired outcome.

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