LONG-TERM WEARING MINIMALIST FOOTWEAR ASSOCIATED WITH BIOMECHANICAL CHANGES DURING WALKING

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The aim of this study was to investigate the changes in kinematics and kinetics variables during walking barefoot and minimalist footwear between two different group of experience and nonexperience with minimalist footwear. Participants performed randomly 8 trials in barefoot and minimalist footwear. Statistics analyses were used to determine differences between ankle joint kinematics and kinetics variables defined as $p<0.05$. Results were assessed in terms of the substantive exchangeability of using Effect Size (ES). Results of the current study suggested that experience with minimalistic footwear doesn't influence walking pattern in this footwear and does not affect walking even barefoot.

KEYWORDS: Vivobarefoot, younger adult, gait analysis, sole, kinematics, kinetics

INTRODUCTION: Minimalist Barefoot Technology (MBFT) footwear has becoming very popular in current decade (Esculier et al., 2015). Based on studies on barefoot walking, proprioception increases, but the urban environment carries several risk factors for barefoot walking. For this reason, it is well known that aim of companies have started to produce minimalist footwear as a substitute for barefoot walking. (Kennedy & Inglis, 2002). They represent it as the best substitute for walking barefoot which have a health benefit to musculoskeletal system. Compared to normal footwear. this type of footwear is very flexible. has a minimal sole. neutral drop between the heel and toe. low weight. minimal damping of tread. absence of foot movement support and stability (Sinclair et al., 2013). They are designed to allow maximum function of the foot which consists of 26 bones, 33 joints, 19 muscles and 104 cutaneous mechanoreceptors (Kennedy & Inglis, 2002; Theodore, 2008). Latest studies show both positive and negative effects on the human body when wearing minimalist footwear. Daily use of footwear with a minimalist sole has been shown to positively affect balance and walking efficiency, increasing the sensitivity of sensory mechanoreceptors, activates smaller foot muscles, larger muscles intersecting the ankle joint and increases foot strength (Cudejko et al., 2020). However, the impact of walking in minimalist footwear on the human foot is less clear to us and still unclear whether the experience with minimalistic footwear influence foot pattern. We are missing Therefore. the aim of this study was investigating the changes in kinematics and kinetics variables during walking in different conditions between participants which are familiar and unfamiliar with minimalist footwear.

METHODS: Sixteen participants were recruited into this study. They were divided into two groups. which both contains 4 female and 4 males. First group contain participants with experience with minimalist footwear and second group participants without any experience. Inclusion criteria for experimental group were age between 18 to 36 years. be familiar with minimalist footwear more than one year with minimum frequency of wearing 3 times per week. Exclusion criterion for both groups were history of any disfunction or surgery with lower extremities and lumbar spine. The basic anthropometric data (age. height. weight) were for experienced group 29.90 ± 5.00 y. 181.63 ± 6.95 cm. 77.13 ± 8.27 kg and for nonexperienced group 26.19 ± 3.71 y. 164.25 ± 4.56 cm. 62.25 ± 7.81 kg. All participants performed 8 trials randomly in minimalist footwear Vivobarefoot (Primus Knit. Vivobarefoot Ltd. London. UK) with 3mm sole and barefoot. Starting point were marked by small cone before first force plate at least 5 meters. Lastly the probands were instructed to focus on yellow line stuck to the ground at opposite side. In accordance with the guidelines of the University of Ostrava Ethics and Research committee and according to Helsinki declaration. an informed consent was obtained from each participant.

Data Collection: Motion capture system Qualysis Track manager (QTM) contain ten infrared cameras to detect retroreflective markers (9× Oqus 700+. 1× Oqus 510+. Qualisys. Inc. Gothenburg. Sweden) located at a height of 2.5 m around the laboratory were used for capturing walking trials at a sampling frequency of 240 Hz. Ground reaction force (GRF) data were collected from three force plates (Kistler 9286AA. 9281CA and 9287CCAQ02. Kistler Instruments AG. Winterthur. Switzerland) at a frequency of 2160 Hz. Retroreflective markers were bilaterally attached on probands with differences at foot model using only heel clusters. first and fifth metatarsus (Leardini et al., 2007). Participants performed all the trials at the control speed 3.7 – 5.2 km/h controlled by two photocells (P-2RB/1. EGMedical. Ltd. Czech Republic) located at intervals of 2 m along the runway.

Data analysis: Software's QTM (Track Manager; Qualisys. Sweden. Göteborg) and Visual 3D v6 (C-Motion. USA. Germantown) were used for processing kinetics and kinematics data. Kinematics data were filtered similarly at 12Hz (Weir et al., 2019). Coordinate systems of the lower extremity segments. proximal and distal ends were ascertained from the calibration trials (Hamill et al., 2013). Ankle three-dimensional joint angles and net internal were calculated using an x-y-z Cardan rotation sequence and a Newton-Euler inverse dynamics technique (Robertson et al., 2014). Entire stance phase and whole gait cycle served for determined angles in the lower extremity joints. All data are presented as mean±SD. Normality of data was confirmed using Shapiro-Wilk test. The calculation of the effects size (ES) was also included. ES was classified as trivial = <0.20. small = 0.20-0.50. moderate = 0.50-0.80 or large >0.80 (Cohen, 1988). Significance was defined as $p<0.05$ and the analysis were conducted by means of SPSS (v.23 IBM).

RESULTS: Descriptive statistics with means and standard deviations are present in Tables 1 and 2 which are enriched with ES for two conditions. At all variables at right ankle for minimalist footwear were not found statistical significance differences. It is apparent from Table 1 that large ES was found only at mediolateral terminal stance (ES=0.81) in comparison experience and nonexperience group. Moderate ES were found at dorsiflex ankle angle (ES=0.54), VGRF 2nd peak (ES=0.54) and mediolateral mid stance (ES=0.58). We achieved small effect at flexion ankle angle (ES=0.44), anterior-posterior loading response and terminal stance (both ES=0.49). Table 1 also reported trivial significant for the other variables.

Table 1: Kinematic variables of walking in minimalist footwear at right ankle

Right leg	Experience Mean ± SD	Non-experience Mean ± SD	ES	P-value
Dorsiflex ankle angle (°)	86.06 ± 4.82	83.85 ± 3.20	0.54	0.195
Eversion ankle angle (°)	-14.14 ± 5.84	-13.16 ± 5.30	0.17	0.721
Flexion ankle angle (°)	59.06 ± 3.64	57.31 ± 4.18	0.44	0.505
Foot initial contact (°)	-90.34 ± 6.09	-90.87 ± 4.63	0.09	0.721
VGRF 1st. peak (%/BW)	123.02 ± 23.51	127.66 ± 36.72	0.15	0.878
VGRF 2nd. peak (%/BW)	114.36 ± 18.72	132.31 ± 42.98	0.54	0.798
Anterior-Posterior loading response (%/BW)	20.28 ± 3.85	22.88 ± 6.37	0.49	0.574
Anterior-Posterior terminal stance (%/BW)	-24.71 ± 3.96	-27.74 ± 7.74	0.49	0.654
Mediolateral mid stance (%/BW)	5.81 ± 1.24	7.32 ± 3.46	0.58	0.195
Mediolateral terminal stance (%/BW)	4.51 ± 1.20	7.40 ± 4.92	0.81	0.442

VGRF – vertical ground reaction force. BW – body weight. ES – effect size. SD – standard deviation

As shown in Table 2, no statistically significant differences were found. On the other hand, we can see large effect size at dorsiflex ankle angle (ES=0.92). Anterior-posterior loading response (ES=0.77), mediolateral mid stance (ES=0.79) and mediolateral terminal stance (ES=0.55) shows moderate ES.

Table 2: Kinematic variables of walking barefoot at right ankle

Right leg	Experience Mean ± SD	Nonexperience Mean ± SD	ES	P-value
Dorsiflex ankle angle (°)	78.91 ± 2.58	76.73 ± 2.09	0.92	0.130
Eversion ankle angle (°)	-10.68 ± 5.97	-11.78 ± 5.41	0.19	0.798
Flexion ankle angle (°)	61.11 ± 6.31	58.47 ± 4.44	0.48	0.382
Foot initial contact (°)	-83.74 ± 4.74	-85.26 ± 4.38	0.33	0.382
VGRF 1st. peak (%/BW)	119.30 ± 13.94	118.96 ± 10.48	0.03	0.798
VGRF 2nd. peak (%/BW)	118.05 ± 4.24	115.35 ± 10.41	0.34	0.798
Anterior-Posterior loading response (%/BW)	19.05 ± 3.66	21.35 ± 2.06	0.77	0.279
Anterior-Posterior terminal stance (%/BW)	-25.83 ± 3.38	-26.06 ± 3.63	0.07	0.959
Mediolateral mid stance (%/BW)	5.11 ± 1.23	6.50 ± 2.15	0.79	0.161
Mediolateral terminal stance (%/BW)	4.23 ± 1.54	5.32 ± 2.33	0.55	0.279

VGRF – vertical ground reaction force. BW – body weight. ES – effect size. SD – standard deviation

DISCUSSION: The aim of this study was to investigate changes in biomechanical variables during barefoot walking and minimalist footwear between participants with and without minimalist footwear experience. Our results show that there are no differences in the biomechanics of walking in minimalist footwear between the group with and without experience with minimalist footwear. Walking in minimalist footwear strengthens the plantar and ankle muscles. Due to the wider part of the shoe, three-point foot support is also enabled. As a result, we expect the experience group could report more absorption at anterior-posterior loading response and to generate more power at the anterior-posterior terminal stance. This suggestion was not confirmed, and it seems that experience with minimalist footwear doesn't influence walking pattern at kinetic variables. Surprisingly very little information was found about comparing walking barefoot and minimalist footwear. Only one study deal with barefoot walking and minimalist footwear, where they found increased local dynamic stability and reduced gait variability during walking in minimalist footwear compared to barefoot walking in younger and older adults (Petersen et al., 2020). More studies looking at the biomechanics of running in minimalist footwear, or studies looking at the differences between barefoot walking and neutral footwear (Perkins et al., 2014; Sun et al., 2020; Xu et al., 2017). There were found differences in anterior posterior 2nd peak during barefoot walking compared to neutral footwear, which has a larger shock absorbing sole (Xu et al., 2017). A similar result was observed in our study comparing barefoot walking and minimalist footwear. However, more research is needed in this area as there is still a lack of studies looking at the long-term effect of wearing minimalist footwear. Furthermore, these data should be interpreted with caution as these gait measurements only consider one type of minimalist footwear. Participants in the experience group who wear minimalist footwear for more than 1 year may be using a different brand of footwear that may have different characteristics. Finally, we considered this study as a pilot study, involving a smaller sample of probands.

CONCLUSION: The aim of this study was to investigate the effect of walking in minimalist footwear and barefoot in people with different experiences of minimalist footwear. Preliminary results of this study suggest that experience with minimalist footwear has no significant effect on kinematic and kinetic data. Similarly, experience with minimalist footwear does not affect the pattern of barefoot walking.

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