Influence of Different Types of Footwear on Sport Performance Characteristics, in Long Distance Running - Case Study

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Abstract

Over the past decade, long-distance running shoes have gone through a continuous process of technologization. By 2017, major footwear manufacturers were focused on making running shoes as light as possible, made of the thinnest material possible to maximize athletic performance. Since 2017, the sports equipment company, Nike, has been producing the Nike Vaporfly shoe, the first footwear model with a carbon plate in the sole. Currently, the most feasible way to break the 2-hour marathon barrier is to reduce the energy cost of running. Thus, improving the equipment used during running is important. The aim of this study is to highlight the differences in the economics of running with different types of footwear. Thus, the aim was to collect these parameters which are influencing the running economy on a 26-year-old male athlete who used different running shoes in pre-determined training sessions. The characteristics of running dynamics were measured using Garmin's smart watch (Forerunner 955), heart rate monitoring belt (HRM-pro) and device (dynamic pod) from the same manufacturer. The parameters analyzed after data collection, were: average ground contact time, average vertical ratio, power during running, and heart rate data. Comparison of these indicators with the footwear used, shows that running shoes with carbon plate bring benefits on running economy. Choosing the right shoes for training or competition is an important factor in improving these parameters.

***Keywords**: running, marathon, running economy, running shoes.*

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1. Introduction

Over the past decade, running shoes have undergone a continuous process of technologization, ranging from a minimalist sole to the introduction of carbon plates and manufacturing from recyclable products. Although the premier discipline of long-distance running, the marathon, was introduced at the 1896 Summer Olympics, one of the first pairs of running shoes dates back to 1865 (Larson, 2012). Nowadays, competition from sporting goods manufacturers is increasing, which requires continuous product innovation.

In 2017, sporting goods manufacturer Nike introduced the first carbon plate technology in long-distance running shoes with the Nike Vaporfly 4%. The aftermath of this introduction resulted in all athletes wearing these shoes setting world records over 100km, marathon, half marathon and 15km the following year (Burns &Tam, 2020). In October 2019, athlete Eliud Kipchoge becomes the first runner to complete the 42.195 km marathon distance in less than 2 hours. This with a pair of prototype running shoes, Nike Vaporfly Next%. A 2005 study attempted to predict the possible limits of the men's marathon world record (Navil & Whyte 2005), which was beaten by the Kenyan runner by nearly 4 minutes. The age of technology continues to have a major impact on many sports such as cycling, swimming, and the components of athletics (Balmer, Pleasence & Nevill, 2012; Haake, 2009; Dyer, 2016). In 2012, it was suggested that all significant achievements in sports are due to technological improvements rather than the body. Therefore, innovation, design, and application of technology in competitive sports are of great importance to athletes seeking to improve their performance.

In recent years, attention has been drawn to the Nike Vaporfly Next and Alphafly running shoes, whose performance is not considered ethical according to previous findings (Burns & Tam, 2020). The advent of these technologies challenges the philosophy of sport, which is that sports technology requires an ethical foundation rather than an attitude of winning at all costs.

Lighter running shoes lead to an improvement in the energy cost of running (Franz, Wierzbinski & Kram, 2012; Frederick, Daniels & Hayes,

1984). By influencing parameters related to running economy, they help improve athletic performance (Hoogkamer et al., 2016). Nowadays, all running shoes have soles made of different foams to which carbon plates or rods are added to provide better cushioning and mechanical energy return.

2. Objective

The aim of this study was to determine the differences between different running shoes in terms of running economy. The shoes used in this study were: Nike Vaporfly Next%, Nike ZoomFly3, Craft CTM Ultra Carbon 2, Asics MetaSpeed Sky. Figure 1 shows the structure of the Vaporfly shoes.

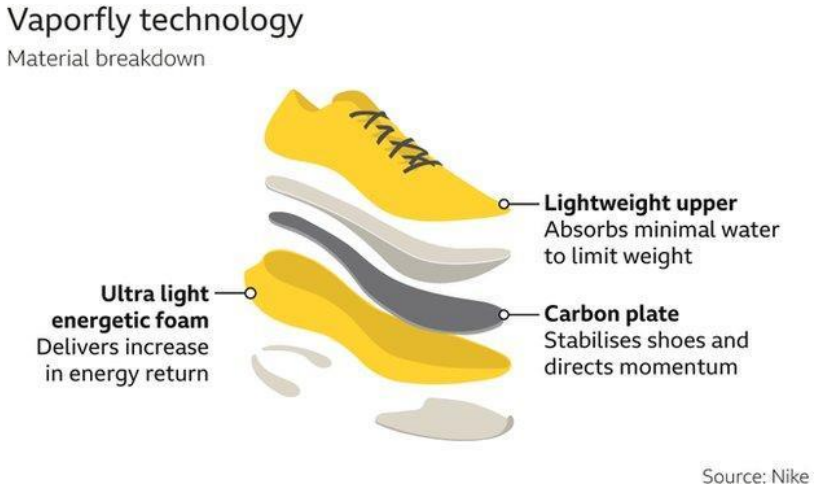

Figure 1. Vaporfly technology (Roan, 2020)

3. Materials and methods

All analyzed data were collected from a 26-year-old amateur voter who is 172 cm tall and weighs 72 kg. The subject has healthy lifestyle habits with an average sleep of 7-9 hours per night and daily activity of 6-10 hours. Clinically healthy, no alcohol, tobacco or drug dependence. An athletic history as a former martial artist and current amateur triathlete has resulted

in a positive body response to the procedure. Willingness to participate in a 4-week training programmed was an important factor in subject selection.

The training programme was designed to test 4 pairs of different running shoes, each used under similar conditions. Running speeds during training were 10 km/hr, 12 km/hr, and 14 km/hr, with each pair of shoes covering a distance of 7 km per session. The Mezocycle began in July 2022 and ran for 4 weeks with 3 training sessions per week held on Mondays, Wednesdays, and Fridays at 06:00 AM. The runs took place on an athletics track that met all the conditions imposed by FRA. Table 1 shows the training distribution.

Table 1. Distribution of workouts per week

	Nike Zoom Fly 3			Nike Vaporfly Next			Craft CTM Ultra 2			Asics Metaspeed SKY		
Week 1	10km/ hr	12km/ hr	14km/ hr									
Week 2				10km/ hr	12km/ hr	14km/ hr						
Week 3							10km/ hr	12km/ hr	14km/ hr			
Week 4										10km/ hr	12km/ hr	14km/ hr

Data were collected using Garmin sports and fitness tracking devices. Forerunner 945 series watches, whose dedicated platform (https://connect.garmin.com/) supports IT, were used to collect data in an organised format. To eliminate possible errors due to lack of contact or excessive sweating, heart rate was measured using a special wristband (HRM-Tri) from the same manufacturer. The indicators of running dynamics were measured with the device (Garmin Dynamic Pod).

The parameters analysed during the study were: Duration of ground contact (mm), vertical oscillation (cm); the latter were correlated with heart rate and running performance. The report of the parameters are presented in Figure 2.

Figure 2. Garmin Indicators Report

Adherence to the principles of research ethics was a priority, and subjects were well informed about the conduct of the study. After explaining the collection and processing of personal data, informed consent was obtained from the participants.

The results obtained were statistically processed using data analysis and processing programs: Microsoft Excel 2022 and IMB SPSS Statistics 36.

The shoes used in the study were very different: running shoes from three different suppliers, Nike, Craft and Asics, three of them with carbon plates or upper technology, as can be seen in Figure 3.

Figure 3. Running shoes (Top4running.ro 2022)

4. Results

The analysis of Figure 4 shows that there are small differences between pairs of shoes in the parameters related to the duration of ground contact. The Nike Zoomfly 3 recorded the longest ground contact in all 3 training sessions with an average of 239 ms and is also the only shoe that is not made of carbon material. The best times were achieved by the Asics shoes with an average of 218ms in the 3 training sessions, they also have the lowest 5mm drop.

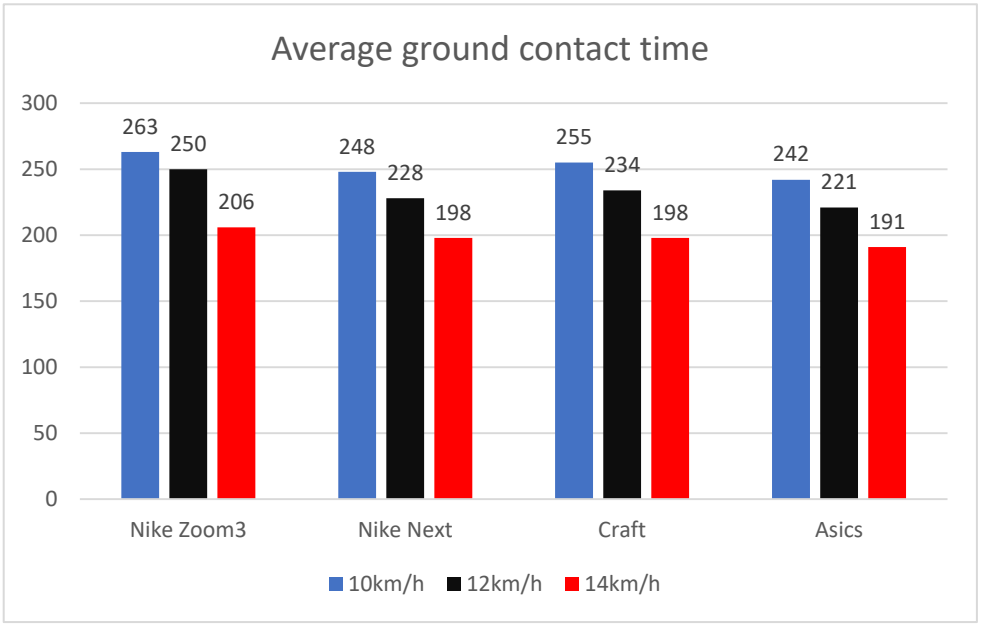

Figure 4. Average Ground contact time (ms)

The analysis of Figure 5, as for the mean value of vertical oscillation during running, a positive correlation is found between a low vertical fluctuation and a higher running speed. When analysing the individual running shoes, the Nike Zoomfly3 brings up the rear of the ranking with an average vertical fluctuation of 10.4 cm. The Asics Metaspeed Sky and Nike Vaporfly Next shoes have the best average values with 9.46 cm and 9.70 cm, respectively.

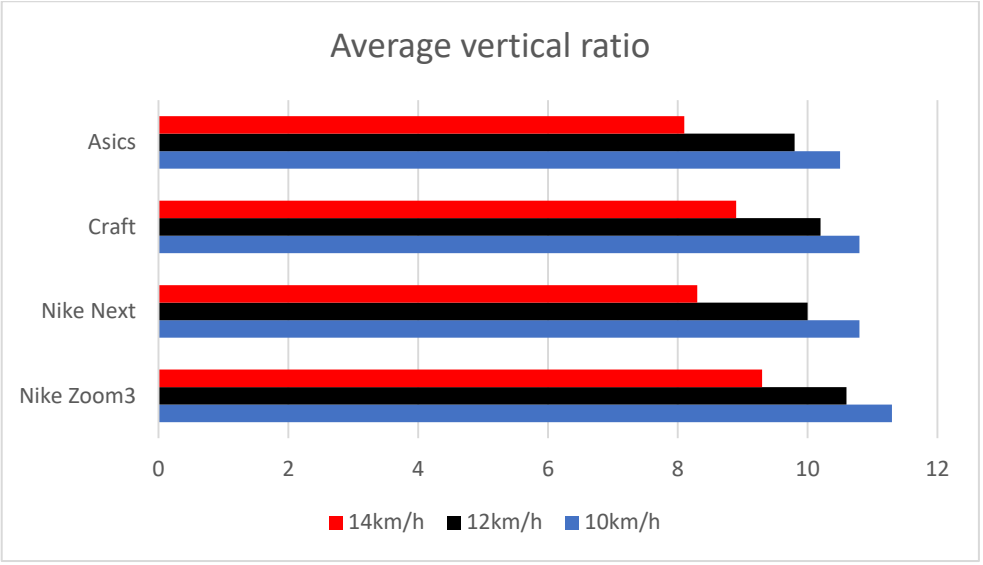

Figure 5. Average vertical ratio (cm)

Analysing Figure 6, a positive correlation between running performance and running speed is observed. The running shoes equipped with Carbon Plate technology are close in terms of running performance, while the pair of Nike Zoomfly3 performs less during the 366W training session.

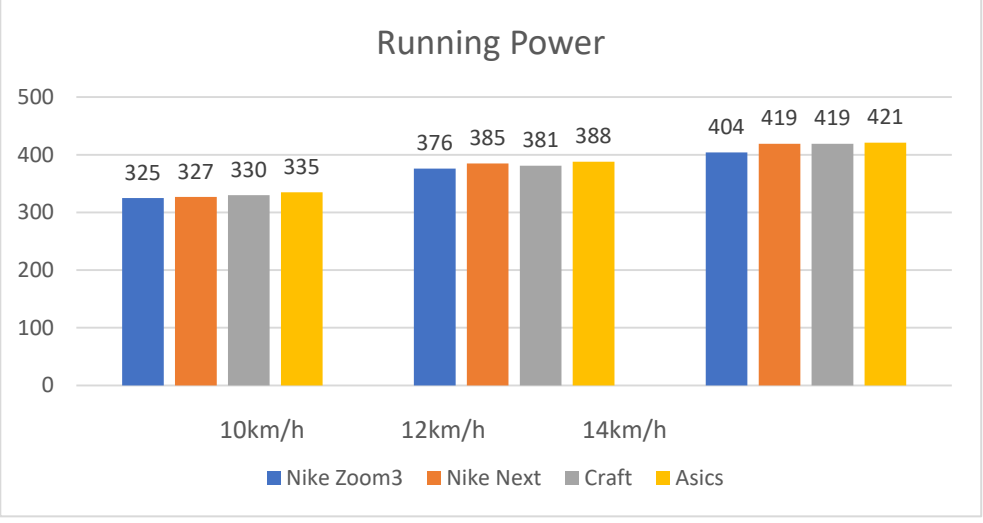

Figure 6. Running Power (W)

5. Discussions

In this study, we compared different pairs of running shoes, analysing 3 indicators of economic running. Regarding the indicator of duration of contact with the ground, we note a difference of 8.79% between the Nike Zoomfly3 shoe, which does not benefit from Carbon Plate technology, and the Asics Metaspeed Sky shoe, which takes first place in the analysis of the indicators. If we compare the weight of the two shoes, we notice a big difference: the Asics shoe is 16.7% lighter. In terms of average vertical oscillation, the comparison of the two shoes shows that the Nike ZoomFly3 generates almost 1 cm more oscillation when running compared to the Asics Metaspeed Sky. Differences are also seen in the parameter related to performance during running, with the Asics manufacturer's shoe having a 3.5% higher average value than the Nike Zoomfly3 shoe.

In the literature, the studies are divided into advantages and disadvantages of the use of carbon fibre technology. With the breaking of the 2-hour marathon mark, much speculation has arisen about the ethics of carbon fibre running shoes. This type of technologization of the running shoe through the introduction of carbon plates increases the stiffness of the shoe and helps to reduce the movement of the metatarsophalangeal joint and increase ground contact reaction force (Madden, Sakaguchi & Tomaras, 2016; Flores, Delattre, Berton & Rao, 2019, Beck et al., 2019, Cicoja et al., 2021).

Other studies suggest that the curved sole shape leads to better running shoes, but not to higher stiffness of the shoe. The carbon plate helps improve the lift of the foot from the ground and reduces the energy cost of running. Current studies show promise for making this innovation mainstream, but more testing is needed (Day & Hahn, 2020).

Analysis of other studies has shown that midsole thickness affects running performance. Lower sole density may be associated with increased metabolic consumption, as greater muscle activity is required to absorb impact forces (Tung et al., 2014). This idea is also supported by other researchers who suggest that running with shoes results in 3-4% lower

oxygen consumption and metabolic performance than running without shoes (Franz et al., 2012).

6. Conclusions

Evaluation of parameters related to running economy has shown that running shoes with carbon plate or carbon rod technology produce improvements in these indicators. However, there are concerns about the limitations of the accepted equipment technology. Given this, ongoing analysis of the technology introduced into the sport is required.

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