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Design, Modeling, and Performance Evaluation of Athletic Insoles Used for Collegiate Vertical Jump Performance in the USA

Andrew Burke, Peter Boahne Sob

Department of Mechanical Engineering, Mount Vernon Nazarene University, Mount Vernon, OH, USA
Email: andburke@mail.mvnu.edu

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Abstract

This research study focuses on the design evaluation and performance enhancement of an athletic insole, intended to improve athletic performance while maintaining long-term durability under repeated use. The proposed athletic insole uses a multi-layer architecture incorporating expanded thermoplastic polyurethane (eTPU), carbon fiber reinforcement, thermoplastic polyurethane (TPU), PORON foam, and high-density ethylene-vinyl acetate (EVA). Each material is selected for a specific mechanical function, including energy return, stiffness control, cushioning, and resistance to compression fatigue. Functional zoning across the forefoot, midfoot, and heel is dynamically engineered to address region-specific loading demands during explosive movement. The primary objective of this project is to develop an optimized insole system that enhances vertical jump performance through improved energy return, force transfer, stability, and impact absorption, without compromising structural integrity over time. To achieve this, mechanics of materials principles are applied to analyze stress distribution, compression deformation, and strain energy storage within the composite layers. Autodesk Inventor finite element analysis (FEA) and Engineering Equation Solver (EES) were used to evaluate the expected mechanical response of the proposed insole design. An Instron machine was also used to perform compression testing on the VKTRY insole. Performance is physically evaluated using the vertical jump test, which serves as the primary metric for assessing changes in lower-body explosiveness. Ten healthy male college students in U.S. men's shoe sizes between 9.5 and 10 took part in standing and running vertical jump testing using both the basic and the VKTRY insoles for the testing. This made it possible for a direct comparison of performance in vertical jumps between the two insole conditions. Theoretical modeling showed controlled deformation and stress distribution within the proposed multilayer design, while the practical testing pro-

vided a physical comparison between basic and optimized performance insoles. The VKTRY insoles provided a higher average vertical jump height than the basic insoles for both testing conditions. The average standing vertical jump increased from 16.74 inches to 17.36 inches, and the average running vertical jump increased from 18.56 inches to 18.90 inches while maintaining good comfort and stability for the athletes. Overall, this research lays the groundwork for the continuous development of a durable, performance-driven sports insole that combines mechanical performance, support, comfort, and long-term durability.

Keywords

Insole, Vertical Jump, Energy, Stability, Compression, Comfort

1. Introduction

In the field of sports engineering, improving athletic performance has become an important area of study, particularly for explosive lower-body movements like jumping [1] [2]. While standard coaching usually centers on intensive training routines and refining body mechanics, athletic footwear and insole design may also affect an athlete's performance [2] [3]. Most conventional shoe inserts are designed mainly for comfort and support [1] [3]. While those features are certainly valuable, standard cushioning is not necessarily designed to improve performance during explosive movements [2] [4]. Performance-focused insoles must be designed to store and return energy, transfer force, and provide stability under repeated loading [2]-[4]. Furthermore, these potential benefits must also be maintained over repeated use, making durability an important part of the design [1] [5]. When durability is overlooked, repeated impacts may cause permanent deformation and reduce performance [5]. This creates a need to study how insole design can balance comfort, performance, and durability [1] [2] [5].

Addressing this need requires understanding how an insole responds to forces during jumping. During a vertical jump, the insole is loaded and unloaded as the athlete moves from landing or preparation into takeoff [1] [2]. This project examines a proposed multilayer insole designed to improve energy return and support [1] [4]. At the core of the design are high-rebound materials like expanded thermoplastic polyurethane (eTPU), which are chosen for their ability to store and release strain energy during loading and unloading [1] [2]. Alongside these responsive layers, high-density ethylene-vinyl acetate (EVA) and specialized PORON foam zones are integrated to stabilize the foot and reduce impact forces, while providing cushioning and support during landing [1] [3]. However, cushioning alone is not enough. The design must also provide suitable stiffness for force transfer [2] [4].

Achieving the right balance of structural stiffness is one of the most challenging aspects of performance footwear engineering, as the insole must be rigid enough

to guide heavy loads without interfering with the foot's natural range of motion [2] [4]. If stiffness is too low, the insole may deform excessively and reduce effective force transfer [3] [4]. A properly supported arch may help distribute forces across the forefoot and midfoot during takeoff [2] [4]. To provide this support, a built-in carbon-fiber reinforcement layer is built into the proposed insole's structural architecture, guiding alignment and stabilizing the foot during takeoff [1] [3] [4]. The insole must also withstand repeated compression to maintain its performance over time [5].

Repeated jumping places cyclic compressive loads on the insole, which can gradually change its material properties [5]. Under repeated loading, some elastomeric foams can experience compression fatigue and reduced energy return [1] [5]. Permanent deformation can change the insole's shape and affect its ability to provide consistent support [3] [5]. Selecting materials that resist fatigue is therefore important for long-term performance [1] [5]. Understanding how the individual layers respond to compression is an important part of evaluating the proposed design [1] [4] [5].

To solve these interconnected challenges of energy return, stiffness, and compression fatigue, this study combines classical mechanics of materials principles with a suite of advanced computational and physical engineering tools. The design lifecycle begins in Autodesk Inventor, where the multi-layer architecture is modeled in 3D and subjected to predictive Finite Element Analysis to map out localized stress concentrations and deformation boundaries. From there, the structural data is brought into Engineering Equation Solver (EES) to model the time-dependent force, stress, strain, displacement, and stiffness response of the insole during the simulated loading cycle. Restricting the participant group to male collegiate students wearing U.S. men's shoe sizes of approximately 9.5 to 10 helped maintain greater consistency in insole fit across the experimental trials [5]. In order to determine whether there are any noticeable differences in jump performance between a basic insole and an existing performance-focused insole, the final experimental stage involves vertical jump testing using basic and VKTRY insoles [2]. For this experimental testing phase, a sample size of ten healthy male collegiate athletes was selected to participate in controlled empirical testing. More consistency in insole fit across the experimental trials was attained by limiting the participant group to male college students with U.S. men's shoe sizes of 9.5 to 10. Ultimately, the primary goal of this research is to develop an optimized, multi-layered athletic insole system that enhances vertical jump performance through superior energy return, force transfer, stability, and impact absorption, without sacrificing structural integrity over time.

2. Methodology

Theoretical Framework and Considerations for Model Derivation of Insole for Optimal Performance

In the field of sports engineering, the true performance of an athletic insole comes

down to a carefully connected balance between user comfort, spatial force transfer, shock absorption, and energy return [1]-[3]. While cushioning and general foot comfort are essential for protecting joints and preventing injuries, these are ultimately passive features that do not actively increase an athlete's explosive power [2] [4]. To actually boost physical output during fast, high-impact movements, structural stiffness becomes the defining variable used to evaluate and tune an athletic performance shoe insole [2]-[4]. A precisely calculated stiffness profile works like an efficient lever arm beneath the foot, preventing localized energy loss at the flexible joints and redirecting torsional impact forces toward the body's power-producing zones [3] [4]. To model this behavior mathematically, we can start by treating the insole assembly as a basic, macroscopic elastic spring. Picture a simple free-body force diagram of a competitive athlete initiating a vertical jump. The athlete's foot drives a downward vertical force (F) into the footwear, which is met by an equal and opposite vertical ground reaction force pushing up from the ground. This quick interaction causes an immediate vertical compression deformation (δ) throughout the insole material (**Figure 1**).

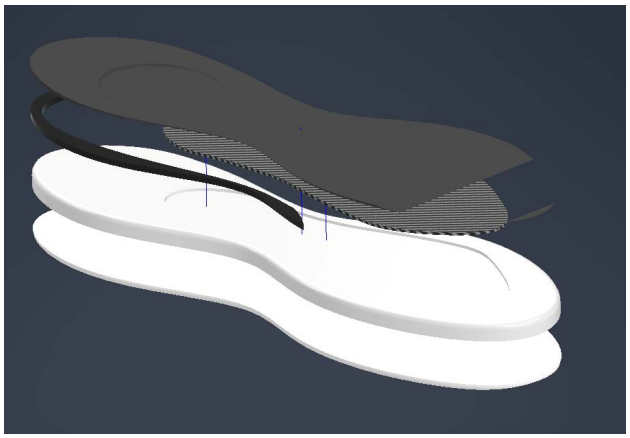


Figure 1. Exploded view of the proposed five-layer athletic insole design by Autodesk Inventor.

Using this physical framework, the foundational model of linear spring stiffness in footwear design, as established by [2] [4], is expressed as:

$$k = \frac{F}{\delta} \tag{1}$$

Where $k = stiffness\left(\frac{N}{mm} or \frac{N}{m}\right)$, $F = applied\ force(N)$ and $\delta = displacement\ or\ deformation(mm\ or\ m)$.

The overarching stiffness relationship defined by Equation (1) gives us a clear mathematical understanding of how the insole behaves as one complete system, but it does not fully account for how the individual layers deform and interact with each other during actual athletic movements. To understand these subtle shifts, we need to build a separate model for deformation that factors in real-world boundaries and

material thicknesses [1] [5]. When an athlete applies a rapid, dynamic force during a competition, the insole's shape is constantly changing. We can track this using three main geometric parameters: the initial uncompressed thickness (T_0), the instantaneous compressed thickness (T_t), and the resulting net change in thickness (ΔT), which represents the total compression deformation. To establish a continuous, time-dependent mathematical logic for this spatial behavior across the stance phase, the mechanical function for total insole displacement is defined as:

$$\delta(t) = T_0 - T_t(t) \tag{2}$$

where $\delta(t)$ = *time – dependent vertical displacement function* (*mm or m*), T_0 = *initial uncompressed thickness* (*mm or m*) and $T_t(t)$ = *instantaneous compressed thickness as a function of time* (*mm or m*).

Because the ground reaction forces spike and drop throughout the phase of a jump, this deformation is highly dynamic and must be written as a continuous function of displacement over time [2] [5]. It can be difficult to accurately predict how advanced elastomeric materials deform over time because of their viscoelastic properties [1] [5]. However, a reliable starting point can still be developed by using continuum mechanics to analyze the behavior of the different layers in the insole [1]. For this stage of the model, we can rely on the general equations of material elasticity to isolate how our different layers behave, defining a composite's raw resistance to deformation through Young's Modulus [1] [5]:

$$E = \frac{\sigma}{\varepsilon} \tag{3}$$

where $\sigma = stress(\text{MPa})$ and $\varepsilon = strain$.

By breaking down this elastic modulus, we can directly connect pure material science back to our real-world insole geometry. In this continuum model, the normal stress (σ) is simply the athlete's downward force divided by the localized cross-sectional contact area (F/A), while the engineering strain (ε) is the normalized change in material thickness ($\Delta T / T_0$). Plugging these physical dimensions into our elasticity model bridges the gap between raw material properties and localized structural spring rates [1] [4] [5] (**Figure 2**).

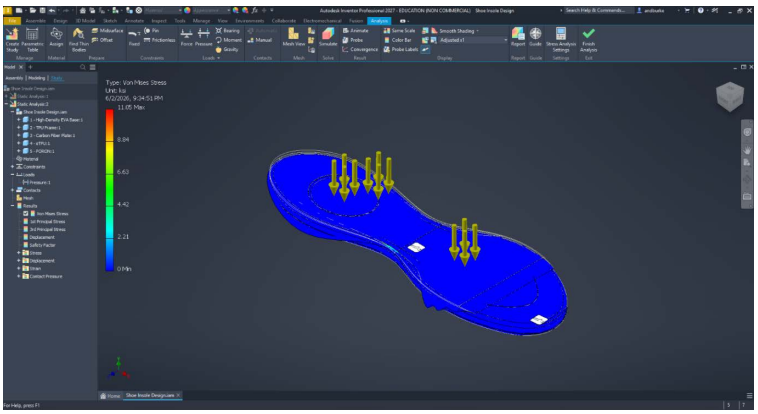


Figure 2. Autodesk Inventor FEA model showing applied loading conditions.

Based on the numerical data gathered from the Finite Element Analysis (FEA) model, the localized internal expressions are evaluated. The formula for localized engineering stress extracted from the FEA spatial boundary is defined as:

$$\sigma_{FEA} = \frac{F_{applied}}{A_{regional}} \tag{4}$$

where σ_{FEA} = stress, $F_{applied}$ = *compression* (N) and $A_{regional}$ = *surface contact area* (m^2 *or* mm^2)

The corresponding equation for engineering strain validated by the FEA displacement data is written as:

$$\varepsilon_{FEA} = \frac{\delta_{FEA}}{T_0} \tag{5}$$

where ε_{FEA} = strain, δ_{FEA} = *compression displacement* (m *or* mm) and T_0 = *Initial thickness* (m *or* mm)

Because our proposed design relies on functional zoning, meaning the total surface area (A) and stack height thickness ($L = T_0$) change continuously as you move from the thick heel to the thin carbon-fiber arch, the integrated equation used to compute structural stiffness from material properties, as outlined by [1] [5], becomes:

$$k = \frac{AE}{L} \tag{6}$$

where $k = stiffness\left(\frac{N}{mm} or \frac{N}{m}\right)$, $A = area\left(mm^2 \text{ or } m^2\right)$, E = *effective Young's Modulus* (MPa) and $L = \frac{thickness}{height}\left(T_0\right)\left(mm \text{ or } m\right)$.

While this structural formula is perfect for guiding how we layer and position our eTPU, carbon-fiber, and EVA components, it assumes an ideal, stationary environment that leaves out the high-velocity impacts and long-term wear felt during an actual sports competition [5]. Polymeric foams and composite plates are highly time-dependent materials, meaning they naturally stiffen up when slammed with high-velocity forces and progressively soften after thousands of heavy impact cycles [1] [5]. Because of this, our theoretical modeling must conclude with an evaluation of dynamic stiffness during extended athletic use [2] [3] [5]. This dynamic framework captures real-world behavior under explosive conditions by tracking the ratio between peak kinetic impact force ($F_{\max}$) and the maximum kinematic compression displacement ($\delta_{\max}$) recorded in real time [2] [3]. To monitor how structural fatigue and internal energy dissipation degrade this jumping advantage over hours of repeated use, the standard model for dynamic stiffness is written as:

$$k_{dynamic} = \frac{F_{\max}}{\delta_{\max}} \tag{7}$$

3. Results and Discussion

3.1. Data Used to Evaluate the Mechanical Model

To evaluate the mathematical model developed in this study, the proposed de-

signed insole was analyzed using finite element analysis (FEA) within Autodesk Inventor Professional 2027. A static compressive loading condition representative of an athlete during the ground contact phase of a maximal vertical jump was applied. The pressure load was distributed over the primary heel and forefoot regions to simulate realistic loading conditions during explosive athletic movement.

The following experimental and simulation parameters were used throughout the analytical model and numerical validation (Table 1).

Table 1. The mechanical and simulation parameters and data used in the analytical and finite element models.

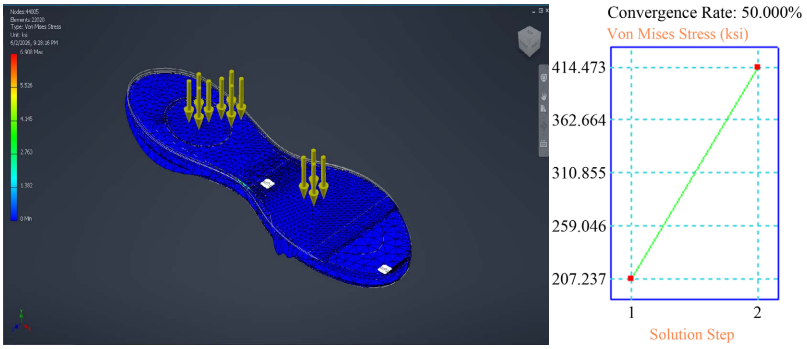
Parameter	Symbol	Value	Unit
Applied pressure	P	25	psi (0.172 MPa)
Total loaded contact area	A	12.15	in^2 (7839 mm^2)
Applied compressive force	F	303.8	lbf (1351 N)
Initial insole thickness	T_0	12.2	mm
Maximum displacement	δ_{max}	5.27	mm
Maximum Von Mises stress	σ_{VM}	47.63	MPa
Maximum engineering strain	ε	0.4318	dimensionless
Effective Young's modulus	E	110.3	MPa
Linear stiffness	k	256.6	N/mm
Structural stiffness	$k_{material}$	70,881	N/mm
Dynamic stiffness	$k_{dynamic}$	256.6	N/mm
Minimum safety factor	SF	1.2	—

Note: These parameters served as the input values for both the analytical equations developed in this research and the numerical finite element simulations. The analytical and FEA results are internally consistent under the shared model inputs. Because the EES calculations use displacement and material parameters obtained from FEA, this agreement is not independent validation. Vertical jump tests used commercially available VKTRY insoles, not the proposed five-layer design, and therefore do not validate the proposed design.

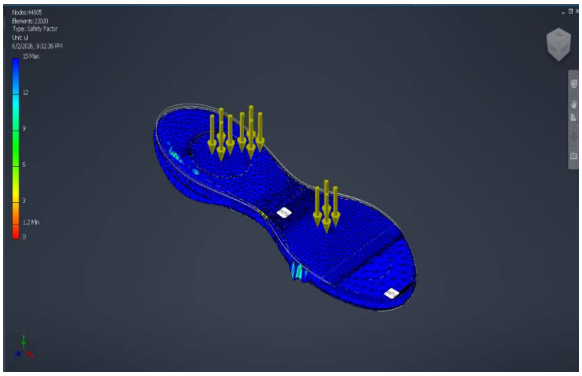
3.2. Results of Autodesk Inventor

Finite element analysis was performed using Autodesk Inventor to evaluate the structural behavior of the multilayer insole under the prescribed loading conditions. The model consisted of five material layers including a high-density EVA base, embedded eTPU energy-return foam, carbon fiber plate, TPU stability frame, and PORON comfort layer. Individual material properties were assigned to each body, and bonded contacts were used to simulate the completed assembly.

A distributed pressure of 25 psi was applied to the heel and forefoot loading regions while the bottom support surfaces were constrained to represent the interaction between the insole and the shoe midsole during ground contact as shown in Figure 3.



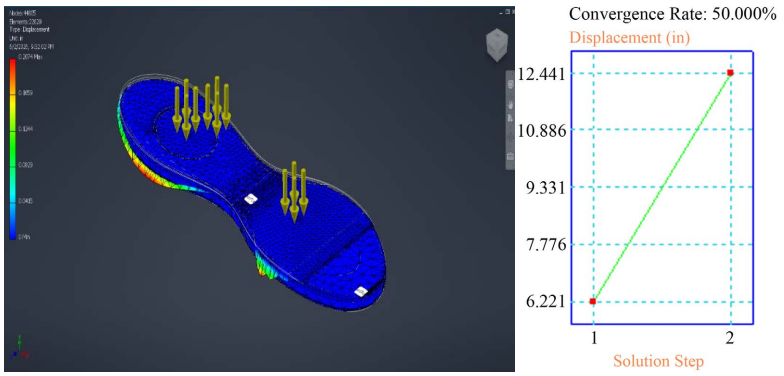
(a) (b)



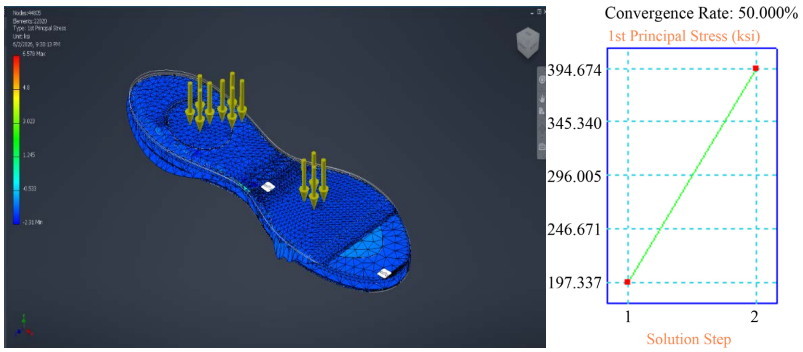
(c)

Figure 3. (a) Distributed pressure applied at the heel and forefoot of the proposed insole, (b) Von Mises stress convergence results from the finite element analysis, (c) Von Mises stress distribution applied to the proposed multilayer insole.

The numerical simulation shown in **Figure 3(a)-(c)** revealed a maximum Von Mises stress of 47.63 MPa, occurring near the transition between the loaded forefoot region and the carbon fiber reinforcement. This stress concentration is expected because the carbon fiber plate increases local stiffness and redirects load through the surrounding elastomeric layers. The predicted stress remained below the allowable strength of the selected materials, resulting in a minimum safety factor of 1.2, indicating that structural failure was not predicted under the simulated loading conditions.



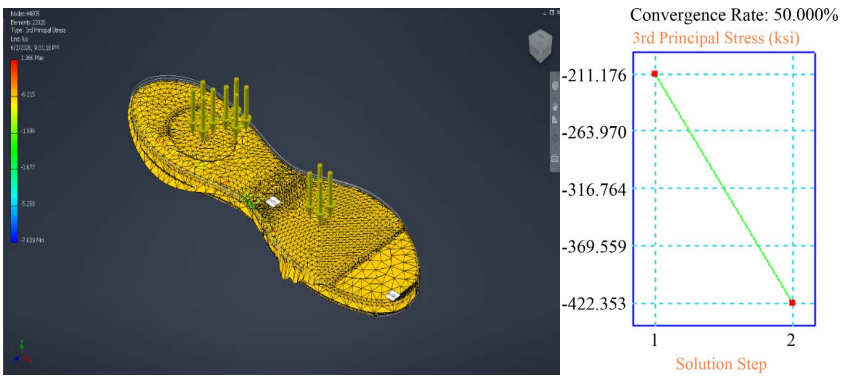
(a) (b)



(c) (d)

Figure 4. (a) Von Mises stress distribution applied to the proposed multilayer insole, (b) Displacement convergence results from the finite element analysis, (c) Displacement distribution applied to the proposed multilayer insole, (d) First principal stress convergence results from the finite element analysis.

The displacement analysis shown in **Figure 4(a)-(d)** revealed a maximum vertical compression of 5.27 mm, representing approximately 43.2% compression of the original 12.2 mm multilayer stack. The deformation was distributed primarily within the compliant eTPU and PORON layers, while the carbon fiber plate remained relatively rigid and effectively transferred load between the heel and forefoot regions. **Figures 3-4** show the simulated stress and displacement response under the assigned constitutive assumptions. The linear elastic model does not establish the absence of yielding or permanent deformation in real foams. The static model predicts deformation under the applied load. Recovery after unloading and long-term durability cannot be established without unloading and cyclic testing. This is a possibility for comfort and safety for the athlete during a vertical jump when using the insole. This is due to the fact that the material behaves like a perfectly elastic material under the applied load.



(a) (b)

Figure 5 (a) First principal stress distribution applied to the proposed multilayer insole, (b) Third principal stress convergence results from the finite element analysis.

The first and third principal stress distributions are shown in **Figure 5(a)-(b)**, demonstrating the expected tensile and compressive loading states within the

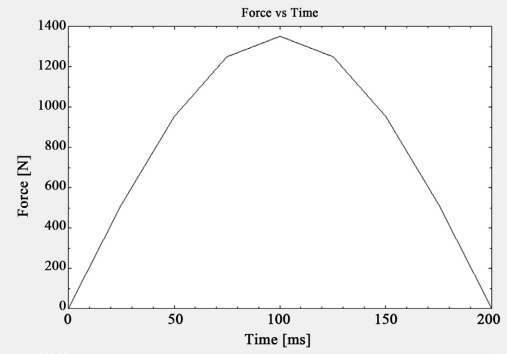
composite structure. Compression dominated the loaded heel and forefoot regions, while localized tensile stresses developed adjacent to the carbon fiber reinforcement due to bending stress of the multilayer assembly. At this stress, the athlete will begin to experience physical discomfort, leading to injury; therefore, the stress in the insole must not approach this condition during a vertical jump. Overall, the Autodesk Inventor FEA results demonstrated that the proposed multilayer architecture is capable of supporting the simulated athletic loading while maintaining structural integrity and providing controlled elastic deformation suitable for energy storage and return during vertical jumping.

3.3. Results of EES/F-Chart Analytical Model

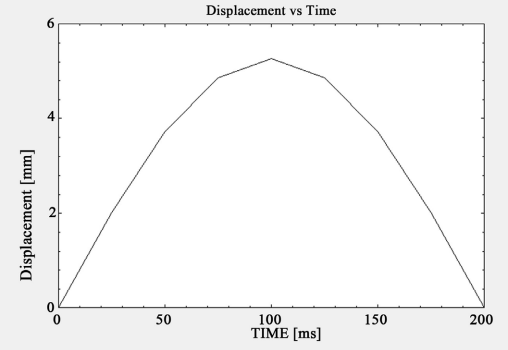
The model developed in this research was simulated using Engineering Equation Solver (EES) to test the time-dependent response of the proposed insole during the ground contact phase of a vertical jump. The governing equations describing stiffness, displacement, stress, strain, and dynamic structural behavior were evaluated using the material and geometric properties extracted from the Autodesk Inventor finite element analysis. The analytical model predicted a peak compressive force of 1,351 N, corresponding to the distributed loading applied during the finite element simulation. The resulting maximum displacement was 5.27 mm, producing an engineering strain of 0.4318 and an effective elastic modulus of 110.3 MPa.

Time-dependent simulations demonstrated the expected sinusoidal loading and unloading cycle throughout the 200 ms contact period as shown in **Figure 6**. The force, displacement, stress, and strain increased smoothly from zero at initial contact, reached their maximum values near mid-stance, and returned to zero at toe-off. The resulting force-displacement relationship exhibited approximately linear behavior, supporting the assumption of linear spring behavior used in the stiffness model.

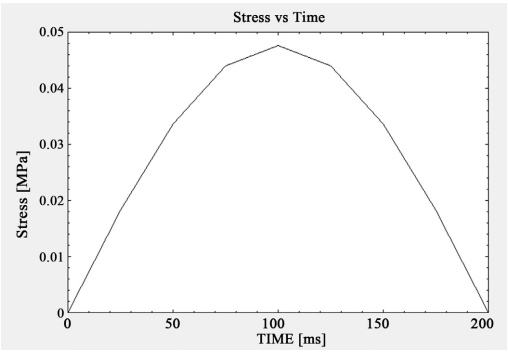
Each EES plot provides a better understanding of how each mechanical parameter changed throughout the simulated loading cycle as shown in **Figure 6**. When the load was removed, the force-time response dropped after increasing from zero at first contact to a maximum compressive force of 1,351 N close to the middle of the loading period. The increasing force delivered to the insole during ground contact and the resulting unloading when the athlete leaves the ground were represented by this loading profile.



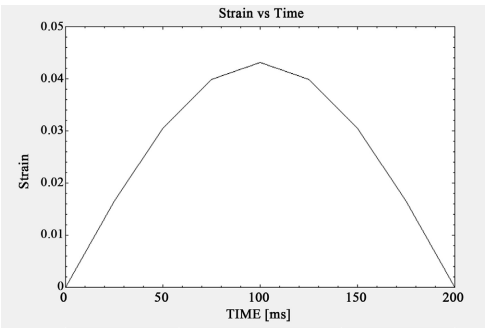
(a)



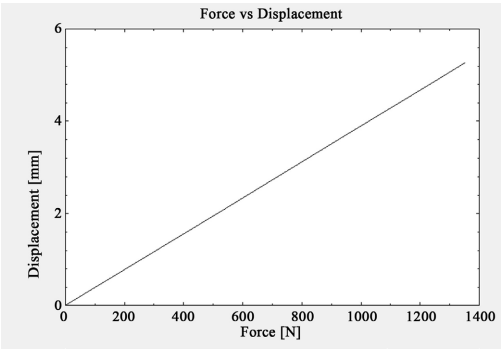
(b)



(c)



(d)



(e)

Figure 6. (a) EES predicted compressive force as a function of time; (b) EES predicted insole displacement as a function of time; (c) EES predicted stress response throughout the simulated loading cycle; (d) EES predicted strain throughout the simulated loading cycle; (e) EES predicted relationship between compressive force and displacement.

The applied force and the displacement response both followed the same pattern as shown in Figure 6(a)-(d). The results revealed how stress, force, displacement, and strain reached an optimal value before failure started, as shown in Figure 6(a)-(d). The insole displacement increased in unison with the compressive force until it reached the expected maximum displacement of 5.27 mm, as shown in Figure 6(b). The calculated stress and strain results also followed the applied loading profile. As the compressive force increased, both values rose and peaked close to the maximum loading point. These results offer an alternate way of determining the degree of deformation produced within the insole under the setting of simulated loads.

The last EES plot compares the compressive force with the displacement. The spring-based assumption included in the analytical model, which connects force to displacement through the insole's effective stiffness, is in line with the linear relationship between these variables. The model produced a dynamic stiffness of 256.6 N/mm, matching the simulation's maximum force and displacement as shown in Figure 6(d). Overall, the Autodesk Inventor analysis's mechanical patterns corresponded with the EES results. While the force and material properties used in EES were based on the same loading condition created for the numerical model, the maximum displacement of 5.27 mm used in the analytical model shown in Figure 6(e) matched the maximum displacement obtained from the FEA. This agreement provides a connection between the analytical equations created in this study and the numerical FEA. More importantly, instead of only showing the maximum values generated by the static FEA, the EES model clearly shows how the expected mechanical response varies during the loading cycle, showing the comfort zone within the area before the optimal point shown in Figure 6(a)-(e).

As a result, the numerical and analytical models offer two complementary ways to analyze the insole design. While EES explains how the main elements react to the loading cycle, Autodesk Inventor pinpoints the locations of stress and deformation within the structure. The next phase of the study looks at the physical compression behavior of the insole before contrasting its use with a basic insole through vertical jump testing, based on the theoretical behavior provided by these two approaches.

3.4. Experimental Compression Testing Using Instron Technology

Following the numerical and analytical evaluation of the insole design, physical compression testing was needed to determine how an actual performance insole responded under an applied compressive load. The five-layer insole designed for this study could not be physically produced within the available timeframe and resources. Because of this, VKTRY performance insoles had to be used for the experimental testing part of this research. The VKTRY insole served as an existing performance-focused insole that was subsequently compared with a basic insole during the vertical jump experiments. As a result, the VKTRY insole was not an

exact physical replica of the proposed five-layer design, but it did serve as an experimental reference for the behavior of an existing performance-focused insole.

In order to see how the VKTRY insole performed when a compressive load was applied, compression testing was done. The test was carried out at a loading rate of 0.50 mm/min, a temperature of 18˚C, and relative humidity of 50%. Since an athletic insole experiences compressive stress as force passes through the athlete's foot and shoe during jumping, the compression test proved beneficial to the study (Figure 7).

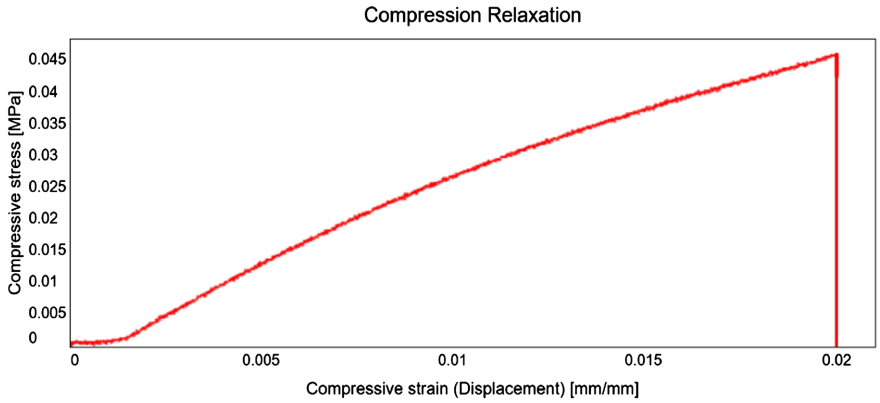


Figure 7. Compression of the VKTRY insole during INSTRON compression testing.

The compression curve shows how the specimen behaved as the applied compressive load increased. At first, the curve changes slowly, but as strain increases, the compressive stress increases more steadily. This suggests that rather than acting as a completely rigid material, the insole gradually deformed as more load was applied. When thinking about sports footwear, this behavior is crucial since an insole needs to be able to deform under load while offering enough structural strength to support the athlete. The results from the compression test revealed that failure/rapture on the insole occurred at a compression stress of 0.045 MPa and at a strain of 0.02. The results also revealed that the insole will begin to experience yielding around a compression of about 0.025 MPa, and the compression of comfort is approximately 0.02 MPa.

The specimen reached a maximum displacement of 1.00 mm and a maximum force of 14.49186 N. A relaxation force of 1.17 N was observed at the end of the test. Examining its physical force and deformation response under compression is the main purpose of the experimental data (Table 2).

Table 2. Experimental compression results for the VKTRY insole specimen.

Experimental Measurement	Result
Maximum Force	14.49186 N
Maximum Displacement	1.00 mm
Relaxation Force	1.17 N

The results should not be considered as direct numerical validation of one another since the physical compression test and the designed multilayer FEA model were performed under different loading conditions. Instead, the Autodesk Inventor and EES models explain the expected behavior of the proposed multilayer design, while the compression experiment offers actual details regarding the behavior of the VKTRY performance insole under compression force during landing in a vertical jump. Overall, these parts of the research provide the mechanical background required for the next stage of the study, where the VKTRY insole was compared with a basic insole during actual standing and running vertical jumps.

3.5. Experimental Vertical Jump Test

After completing the mechanical modeling and compression analysis, experimental vertical jump testing was conducted to evaluate whether differences in jump performance occurred between each insole condition. The VKTRY performance insole was, once again, used as the performance-insole condition, as the proposed multilayer design could not be produced for athlete testing. A basic athletic insole was used as the comparison condition. This made it possible for the study's experiment to determine whether using a performance-focused insole resulted in quantitative changes in vertical jump performance.

Ten male college students in good health who had shoe sizes between 9.5 and 10 took part in the testing. Each participant performed both a standing vertical jump test and a running vertical jump test while using both types of insoles. Each testing condition included three attempts. Due to possible influence on testing orders, the starting insole the participant used was alternated. One participant began with the basic insole, and the next participant began with the VKTRY insole. This same pattern was carried out throughout the experiment. This was done to reduce the influence of fatigue, practice, or familiarity with the testing process (**Figure 8**).

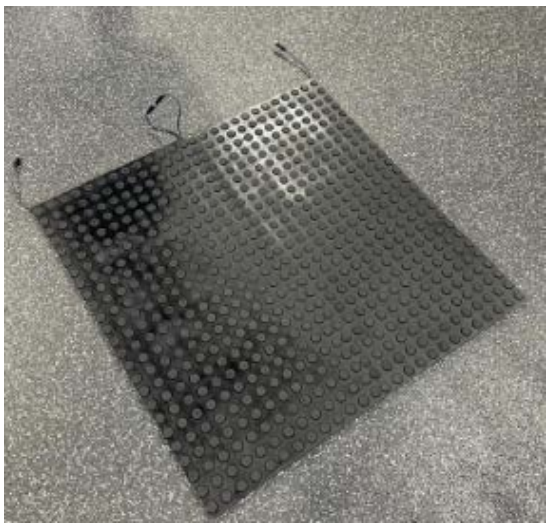


Figure 8. Experimental setup used for standing and running vertical jump testing.

The height of each jump attempt was recorded in inches. The time of flight was then calculated using the jump height measurements and the following equation:

$$t = \sqrt{\frac{8h}{g}} \tag{8}$$

where t is the total time of flight in seconds, h is the measured vertical jump height in meters, and g is the gravitational acceleration, 9.81 m/s^2. Once the three attempts for each condition were complete, the average and best vertical jump values, for time and height, were calculated. Flight time was not used as a separate experimental measurement but rather as a further indication of the recorded jump performance because it was computed directly from vertical height rather than measured separately (Table 3).

Table 3. Participant vertical jump results for basic and VKTRY insoles.

Participant	Basic Standing Avg. (in)	Basic Standing Best (in)	VKTRY Standing Avg. (in)	VKTRY Standing Best (in)	Basic Running Avg. (in)	Basic Running Best (in)	VKTRY Running Avg. (in)	VKTRY Running Best (in)
1	16.27	17.3	18.10	18.5	19.30	19.7	19.30	19.7
2	16.50	17.3	16.90	17.3	16.63	17.3	17.03	17.3
3	13.13	13.4	13.40	14.6	15.40	15.4	14.60	15.4
4	19.43	19.7	21.03	21.3	20.77	21.3	21.43	21.7
5	19.43	20.1	20.37	20.9	21.00	22.0	22.67	23.2
6	16.77	16.9	16.50	16.9	17.57	17.7	17.83	18.5
7	18.23	18.5	18.37	18.9	20.50	20.5	20.77	20.9
8	13.13	13.4	13.00	13.4	16.50	17.7	16.50	17.3
9	15.37	16.1	16.50	16.9	17.57	17.7	18.10	18.5
10	19.17	19.7	19.43	19.7	20.37	20.9	20.77	20.9

This table summarizes each individual's average and best vertical jump heights recorded under each of the four experiment conditions. The complete results, including each of the three jump attempts, calculated flight times, average and best jump heights, and questionnaire responses, are provided in the Appendix.

3.6. Vertical Jump Performance Results

The VKTRY and basic insoles differed in both standing and running vertical jump performance, based on the results of the 10 participants. But for the standing vertical jump specifically, the difference was more noticeable. Using the three-attempt averages, the overall standing vertical jump height was roughly 16.74 inches with the basic insole and 17.36 inches with the VKTRY insole. This shows an average difference between the two conditions of roughly 3.68%, or 0.62 inches.

A similar pattern was seen in the best standing vertical attempts. The collective average was 17.24 inches for the basic insole and 17.84 inches for the VKTRY

insole, resulting in a difference of about 0.60 inches. According to these results, the VKTRY condition generally resulted in higher standing vertical jump heights for this group of participants than the basic-insole condition (Figure 9).

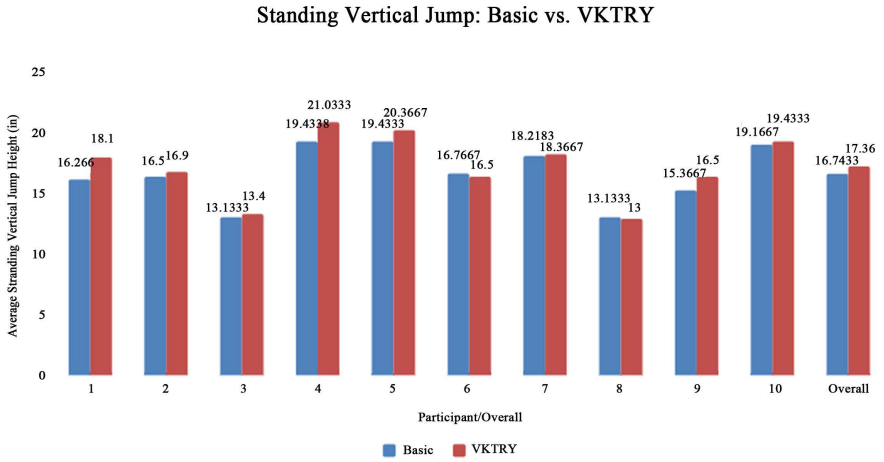


Figure 9. Average standing vertical jump height using the basic and VKTRY insoles.

There was less of a difference between the two insole conditions in the running vertical jump results. The overall average running vertical jump was 18.56 inches with the basic insoles and 18.90 inches with the VKTRY insoles. With VKTRY insoles, this comes to an average increase of 0.34 inches, or 1.83%. The individual data show that not every person has experienced the same effect. With the VKTRY insoles, some subjects demonstrated improvement, while others showed no change at all or even a slight decrease, as shown in Figure 10.

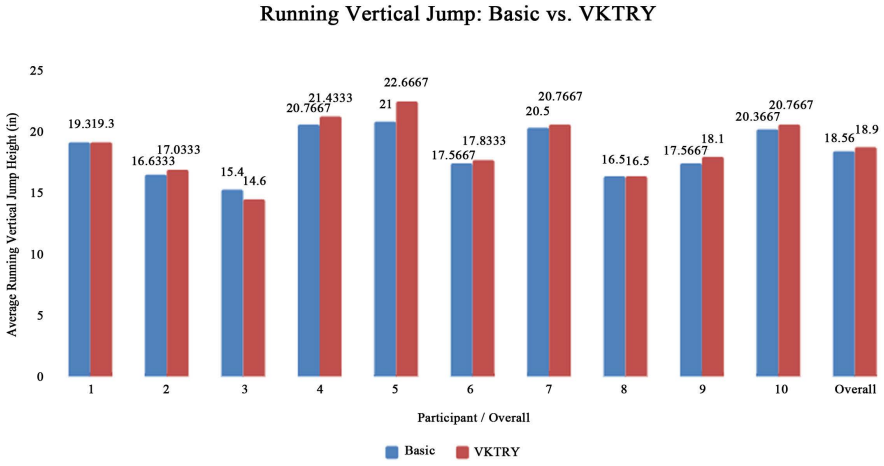


Figure 10. Average running vertical jump height using the basic and VKTRY insoles.

The smaller difference seen during the running vertical jump may be related to the additional variables involved in performing a running approach. The differences between individual attempts can be explained by a variety of factors, including approach speed, foot placement, timing, and jumping technique. Since the

participant starts from a stationary position, the standing vertical jump allows for a more controlled movement. As a result, it can be easier to notice differences related to the insole during the standing jump than during the running jump.

Overall, the results of the experiment show that for both jump types in this participant group, the performance-focused VKTRY insoles corresponded to a higher average jump height than the basic insole. The difference was larger for the standing vertical jump than for the running vertical jump. These results provide an experimental comparison between a basic insole and an existing performance insole and can be analyzed alongside the mechanical behavior observed through the FEA, EES, and compression testing.

3.7. Athlete Questionnaire Results

After testing both insole conditions, each participant responded to a questionnaire in addition to the vertical jump data. The participants' opinions of comfort, stability/support, perceived energy return, and overall performance were recorded using the questionnaire. Each of those categories was rated on a scale from 1 to 10, with 1 being the lowest rating and 10 being the highest rating. Additionally, participants were asked which insole they preferred, if they would suggest it to others, and if they had any further comments.

The questionnaire results are helpful because jump height alone does not describe how an insole feels during athletic activities. An athlete needs a performance insole that is both comfortable enough to use and offers enough support and energy return. Therefore, the questionnaire offers an additional approach for comparing the VKTRY and basic insoles from the eyes of the participants themselves (Figure 11).

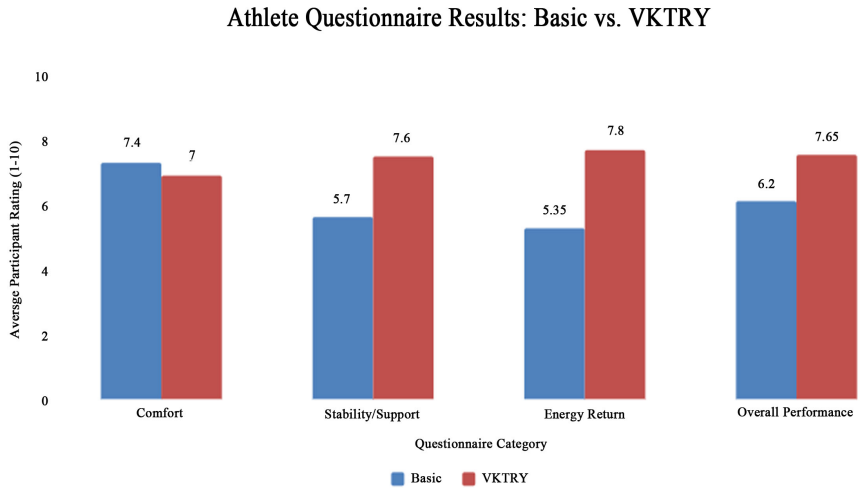


Figure 11. Average participant questionnaire ratings for the basic and VKTRY insoles.

The questionnaire results showed differences in how participants viewed the two insole conditions. The basic insole got a slightly higher average comfort rating of 7.40, compared to 7.00 for the VKTRY insole. On the other hand, the average

scores for stability/support (7.60 against 5.70), perceived energy return (7.80 versus 5.35), and overall performance (7.65 versus 6.20) were more favorable for the VKTRY insole. These findings show that while the basic insole was considered as slightly more comfortable, the VKTRY insole was typically scored higher by the participants in performance-related categories.

The questionnaire responses should be considered together with the vertical jump results rather than as a separate measurement of mechanical performance. For instance, the quantity of mechanical energy returned by the insole is not measured by perceived energy return or stability. Rather, these ratings reflect the participants' views of the differences between the two insole conditions. The Appendix contains the entire vertical jump data as well as each participant's complete questionnaire responses. Note: The energy return rating refers to the participant's opinion of the insole during jumping and should not be taken as a direct mechanical measurement of energy return.

3.8. Discussion

The results from each of the sections of this study offer multiple approaches to determine the potential of athletic insoles with a performance focus. The Autodesk Inventor FEA model looked at how the proposed five-layer insole responded mechanically to an applied load. The model generated a maximum Von Mises stress of 47.63 MPa, a maximum vertical displacement of 5.27 mm, and a minimum safety factor of 1.2 under the simulated loading situation. While the carbon fiber plate was relatively rigid and helped distribute the applied stress through the insole, the deformation mostly happened within the more flexible layers.

The EES analytical model was built on the FEA results by looking at how the mechanical response changed throughout the 200 ms contact period. The model gave an effective Young's modulus of 110.3 MPa, a maximum displacement of 5.27 mm, a maximum engineering strain of 0.4318, and a peak force of 1,351 N. When the applied load increased, the force, displacement, stress, and strain all increased as well. When the load was removed, they all dropped. Additionally, the force-displacement relation showed the modeled insole's stiffness behavior under loading and unloading.

Physical compression testing with INSTRON provided another aspect of the investigation by looking at the behavior of an actual performance insole under compression. The athlete testing then made it possible to determine whether insole variations may be seen when jumping normally in real life. The overall average for both jump types was greater with the VKTRY insoles. On average, the running vertical rose from 18.56 inches to 18.90 inches, and the standing vertical went from 16.74 inches to 17.36 inches. The larger difference in height in the standing vertical may be related to the greater consistency of the movement. Running jumps can make it more challenging to isolate the effect of the additional factors such as approach speed, timing, and foot placement.

It is important to know the difference between the VKTRY experimental results

from the proposed multilayer insole designed in this research. The VKTRY testing served as an experimental reference for looking at how an existing performance-focused insole compared with a basic insole. The FEA and EES models were the main tools used to evaluate the proposed design.

The goal of the proposed five-layer design is to combine multiple mechanical functions into a single insole. The carbon fiber plate offers stiffness and force transfer, the TPU framework offers stability, the PORON layer provides comfort and force distribution, the high-density EVA offers a sturdy supporting base, and the eTPU layer is designed to provide deformation and energy-return properties. Instead of using a single material to offer every essential attribute, the mix of these materials was meant to balance stiffness, deformation, support, comfort, and durability.

When assessing the experimental data, a variety of limitations should also be taken into account. Only ten participants were included, and the participants were limited to a somewhat narrow shoe-size range. Due to human factors such as technique, fatigue, and perhaps motivation, vertical jumping also naturally changes between attempts. Alternating which insole was tested first helped reduce order and fatigue effects, but it could not completely eliminate them. Furthermore, flight time in this study shouldn't be considered as a unique experimental result because it was calculated from the measured vertical leap height rather than measured separately.

The questionnaire results offered additional data about how the participants perceived each insole during testing. The VKTRY insole scored higher on average for stability/support, perceived energy return, and overall performance than the basic insole, which scored slightly higher on average for comfort. This means that even though the VKTRY insole wasn't perceived as more comfortable, participants thought that it was more performance-focused. Future research should develop the proposed insole so its compression behavior can be directly compared with both the basic and VKTRY insoles under identical testing conditions.

4. Conclusions

The purpose of this research was to examine the design and performance of athletic insoles with the objective of designing an insole that could provide performance-enhancing features while remaining supportive and durable for athletes. PORON performance foam, eTPU, carbon fiber, TPU, and high-density EVA were selected for the proposed five-layer insole. Each material was chosen to serve specific purposes within the overall design, such as shock absorption, force transfer, comfort, energy return, and stability.

Autodesk Inventor FEA and an EES analytical model were used to design and examine the mechanical behavior of the proposed design. According to the FEA results, the structure experienced controlled deformation while maintaining a minimum safety factor of 1.2. The loading and unloading behavior during a 200 ms contact period was then represented time-dependently using the EES model.

When taken together, these models offered a theoretical basis for understanding the potential response of the proposed insole under athletic loads.

Compression testing provided information about the physical response of the performance insole, while vertical jump testing enabled its performance to be compared with a basic insole using ten participants. The VKTRY condition resulted in a higher group average for both standing and running vertical jumps during the vertical jump testing. With the VKTRY insoles, the standing vertical average went from 16.74 inches to 17.36 inches, while the running vertical average went from 18.56 inches to 18.90 inches. The standing jump showed a greater difference between the two conditions. Participants' opinions of each insole's comfort, stability/support, energy return, and overall performance were also indicated by the questionnaire responses. Future work should focus on physically manufacturing the proposed five-layer insole and testing it under the same compression and vertical jump testing methods used in this study. A more direct comparison of the three insole conditions would be possible if the basic, VKTRY, and the proposed insoles were tested under the same conditions. The strength of the experimental results would also be improved with a larger participant group.

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Author Contributions

Andrew Burke conducted the research, developed the insole design and models, performed the experimental analysis, and prepared the manuscript. Dr. Boahne Sob provided research guidance and supervision.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

Complete Data of Vertical Jump Testing and Questionnaire

The Appendix contains the complete experimental data acquired from the ten different participants from the vertical jump study. This consisted of each participant's three jumps of standing and running, with both the basic and VKTRY insoles, respectively. The tables include the recorded jump heights, calculated air time, average and best results, questionnaire ratings given, insole recommendation, and any additional comments the participants had. This data was used in calculations for the results presented in Sections 3.4-3.7.

Participant 1

Date: 09/16/2026

Insole Tested First: Basic

Vertical Jump Data

Insole	Jump Type	Trial	Flight Time (s)	Height (in)
Basic	Standing	Attempt 1	0.56	15.4
Basic	Standing	Attempt 2	0.58	16.1
Basic	Standing	Attempt 3	0.60	17.3
Basic	Standing	**Average**	**0.58**	**16.27**
Basic	Standing	**Best**	**0.60**	**17.3**
VKTRY	Standing	Attempt 1	0.61	18.1
VKTRY	Standing	Attempt 2	0.62	18.5
VKTRY	Standing	Attempt 3	0.61	17.7
VKTRY	Standing	**Average**	**0.61**	**18.10**
VKTRY	Standing	**Best**	**0.62**	**18.5**
Basic	Running	Attempt 1	0.63	19.3
Basic	Running	Attempt 2	0.63	18.9
Basic	Running	Attempt 3	0.64	19.7
Basic	Running	**Average**	**0.63**	**19.30**
Basic	Running	**Best**	**0.64**	**19.7**
VKTRY	Running	Attempt 1	0.63	18.9
VKTRY	Running	Attempt 2	0.64	19.7
VKTRY	Running	Attempt 3	0.63	19.3
VKTRY	Running	**Average**	**0.63**	**19.30**
VKTRY	Running	**Best**	**0.64**	**19.7**

Questionnaire Results

Category	Basic	VKTRY
Comfort	8.0	6.0
Stability/Support	5.0	7.5
Energy Return	3.5	7.5
Overall Performance	6.0	7.5

Preference/Recommendation: Prefers VKTRY insoles; would recommend to others.

Additional Comments: None.

Participant 2

Date: 09/17/2026

Insole Tested First: VKTRY

Vertical Jump Data

Insole	Jump Type	Trial	Flight Time (s)	Height (in)
Basic	Standing	Attempt 1	0.57	15.7
Basic	Standing	Attempt 2	0.60	17.3
Basic	Standing	Attempt 3	0.58	16.5
Basic	Standing	**Average**	**0.58**	**16.50**
Basic	Standing	**Best**	**0.60**	**17.3**
VKTRY	Standing	Attempt 1	0.59	16.9
VKTRY	Standing	Attempt 2	0.58	16.5
VKTRY	Standing	Attempt 3	0.60	17.3
VKTRY	Standing	**Average**	**0.59**	**16.90**
VKTRY	Standing	**Best**	**0.60**	**17.3**
Basic	Running	Attempt 1	0.60	17.3
Basic	Running	Attempt 2	0.57	15.7
Basic	Running	Attempt 3	0.59	16.9
Basic	Running	**Average**	**0.59**	**16.63**
Basic	Running	**Best**	**0.60**	**17.3**
VKTRY	Running	Attempt 1	0.59	16.9
VKTRY	Running	Attempt 2	0.59	16.9
VKTRY	Running	Attempt 3	0.60	17.3
VKTRY	Running	**Average**	**0.59**	**17.03**
VKTRY	Running	**Best**	**0.60**	**17.3**

Questionnaire Results

Category	Basic	VKTRY
Comfort	6.0	8.0
Stability/Support	4.0	9.0
Energy Return	4.0	7.5
Overall Performance	6.0	8.5

Preference/Recommendation: VKTRY for athletic performance and basic for

everyday use. Would recommend VKTRY to others.

Additional Comments: VKTRY insoles are stiff.

Participant 3

Date: 09/18/2026

Insole Tested First: Basic

Vertical Jump Data

Insole	Jump Type	Trial	Flight Time (s)	Height (in)
Basic	Standing	Attempt 1	0.53	13.4
Basic	Standing	Attempt 2	0.51	12.6
Basic	Standing	Attempt 3	0.53	13.4
Basic	Standing	**Average**	**0.52**	**13.13**
Basic	Standing	**Best**	**0.53**	**13.4**
VKTRY	Standing	Attempt 1	0.52	13.0
VKTRY	Standing	Attempt 2	0.51	12.6
VKTRY	Standing	Attempt 3	0.55	14.6
VKTRY	Standing	**Average**	**0.53**	**13.40**
VKTRY	Standing	**Best**	**0.55**	**14.6**
Basic	Running	Attempt 1	0.57	15.4
Basic	Running	Attempt 2	0.57	15.4
Basic	Running	Attempt 3	0.57	15.4
Basic	Running	**Average**	**0.57**	**15.40**
Basic	Running	**Best**	**0.57**	**15.4**
VKTRY	Running	Attempt 1	0.57	15.4
VKTRY	Running	Attempt 2	0.55	14.6
VKTRY	Running	Attempt 3	0.54	13.8
VKTRY	Running	**Average**	**0.55**	**14.60**
VKTRY	Running	**Best**	**0.57**	**15.4**

Questionnaire Results

Category	Basic	VKTRY
Comfort	7.0	8.0
Stability/Support	4.0	6.5
Energy Return	3.5	4.5
Overall Performance	5.0	6.5

Preference/Recommendation: VKTRY; would recommend.

Additional Comments: VKTRY is more comfortable and has more support.

Participant 4

Date: 09/17/2026
Insole Tested First: VKTRY
Vertical Jump Data

Insole	Jump Type	Trial	Flight Time (s)	Height (in)
Basic	Standing	Attempt 1	0.64	19.7
Basic	Standing	Attempt 2	0.64	19.7
Basic	Standing	Attempt 3	0.63	18.9
Basic	Standing	**Average**	**0.64**	**19.43**
Basic	Standing	**Best**	**0.64**	**19.7**
VKTRY	Standing	Attempt 1	0.66	20.9
VKTRY	Standing	Attempt 2	0.66	20.9
VKTRY	Standing	Attempt 3	0.66	21.3
VKTRY	Standing	**Average**	**0.66**	**21.03**
VKTRY	Standing	**Best**	**0.66**	**21.3**
Basic	Running	Attempt 1	0.65	20.5
Basic	Running	Attempt 2	0.66	21.3
Basic	Running	Attempt 3	0.65	20.5
Basic	Running	**Average**	**0.65**	**20.77**
Basic	Running	**Best**	**0.66**	**21.3**
VKTRY	Running	Attempt 1	0.66	21.3
VKTRY	Running	Attempt 2	0.66	21.3
VKTRY	Running	Attempt 3	0.67	21.7
VKTRY	Running	**Average**	**0.66**	**21.43**
VKTRY	Running	**Best**	**0.67**	**21.7**

Questionnaire Results

Category	Basic	VKTRY
Comfort	8.5	6.0
Stability/Support	6.0	8.0
Energy Return	6.5	8.0
Overall Performance	6.5	7.5

Preference/Recommendation: VKTRY; would recommend to other athletes.
Additional Comments: VKTRY insoles need to be worn for a little bit to get better comfort, but basic insoles have comfort right away.

Participant 5
Date: 09/22/2026

Insole Tested First: Basic

Vertical Jump Data

Insole	Jump Type	Trial	Flight Time (s)	Height (in)
Basic	Standing	Attempt 1	0.65	20.1
Basic	Standing	Attempt 2	0.64	19.7
Basic	Standing	Attempt 3	0.62	18.5
Basic	Standing	**Average**	**0.64**	**19.43**
Basic	Standing	**Best**	**0.65**	**20.1**
VKTRY	Standing	Attempt 1	0.65	20.5
VKTRY	Standing	Attempt 2	0.64	19.7
VKTRY	Standing	Attempt 3	0.66	20.9
VKTRY	Standing	**Average**	**0.65**	**20.37**
VKTRY	Standing	**Best**	**0.66**	**20.9**
Basic	Running	Attempt 1	0.63	19.3
Basic	Running	Attempt 2	0.68	22.0
Basic	Running	Attempt 3	0.67	21.7
Basic	Running	**Average**	**0.66**	**21.00**
Basic	Running	**Best**	**0.68**	**22.0**
VKTRY	Running	Attempt 1	0.69	23.2
VKTRY	Running	Attempt 2	0.68	22.0
VKTRY	Running	Attempt 3	0.69	22.8
VKTRY	Running	**Average**	**0.69**	**22.67**
VKTRY	Running	**Best**	**0.69**	**23.2**

Questionnaire Results

Category	Basic	VKTRY
Comfort	7.0	7.0
Stability/Support	6.0	8.0
Energy Return	8.0	9.0
Overall Performance	7.0	8.0

Preference/Recommendation: VKTRY; would recommend.

Additional Comments: None.

Participant 6

Date: 09/23/2026

Insole Tested First: VKTRY

Vertical Jump Data

Insole	Jump Type	Trial	Flight Time (s)	Height (in)
Basic	Standing	Attempt 1	0.58	16.5
Basic	Standing	Attempt 2	0.59	16.9
Basic	Standing	Attempt 3	0.59	16.9
Basic	Standing	**Average**	**0.59**	**16.77**
Basic	Standing	**Best**	**0.59**	**16.9**
VKTRY	Standing	Attempt 1	0.59	16.9
VKTRY	Standing	Attempt 2	0.58	16.5
VKTRY	Standing	Attempt 3	0.58	16.1
VKTRY	Standing	**Average**	**0.58**	**16.50**
VKTRY	Standing	**Best**	**0.59**	**16.9**
Basic	Running	Attempt 1	0.61	17.7
Basic	Running	Attempt 2	0.60	17.3
Basic	Running	Attempt 3	0.61	17.7
Basic	Running	**Average**	**0.61**	**17.57**
Basic	Running	**Best**	**0.61**	**17.7**
VKTRY	Running	Attempt 1	0.62	18.5
VKTRY	Running	Attempt 2	0.60	17.3
VKTRY	Running	Attempt 3	0.61	17.7
VKTRY	Running	**Average**	**0.61**	**17.83**
VKTRY	Running	**Best**	**0.62**	**18.5**

Questionnaire Results

Category	Basic	VKTRY
Comfort	9.0	6.0
Stability/Support	8.0	5.0
Energy Return	6.0	8.0
Overall Performance	7.0	7.0

Preference/Recommendation: VKTRY; would not recommend.
Additional Comments: No additional comments.

Participant 7
Date: 09/25/2026
Insole Tested First: Basic
Vertical Jump Data

Insole	Jump Type	Trial	Flight Time (s)	Height (in)
Basic	Standing	Attempt 1	0.62	18.5
Basic	Standing	Attempt 2	0.62	18.5
Basic	Standing	Attempt 3	0.61	17.7
Basic	Standing	**Average**	**0.62**	**18.23**
Basic	Standing	**Best**	**0.62**	**18.5**
VKTRY	Standing	Attempt 1	0.63	18.9
VKTRY	Standing	Attempt 2	0.61	18.1
VKTRY	Standing	Attempt 3	0.61	18.1
VKTRY	Standing	**Average**	**0.62**	**18.37**
VKTRY	Standing	**Best**	**0.63**	**18.9**
Basic	Running	Attempt 1	0.65	20.5
Basic	Running	Attempt 2	0.65	20.5
Basic	Running	Attempt 3	0.65	20.5
Basic	Running	**Average**	**0.65**	**20.50**
Basic	Running	**Best**	**0.65**	**20.5**
VKTRY	Running	Attempt 1	0.65	20.5
VKTRY	Running	Attempt 2	0.66	20.9
VKTRY	Running	Attempt 3	0.66	20.9
VKTRY	Running	**Average**	**0.66**	**20.77**
VKTRY	Running	**Best**	**0.66**	**20.9**

Questionnaire Results

Category	Basic	VKTRY
Comfort	8.0	7.0
Stability/Support	5.0	7.0
Energy Return	3.0	8.0
Overall Performance	5.0	8.0

Preference/Recommendation: VKTRY; would recommend.

Additional Comments: None recorded.

Participant 8

Date: 09/25/2026

Insole Tested First: VKTRY

Vertical Jump Data

Insole	Jump Type	Trial	Flight Time (s)	Height (in)
Basic	Standing	Attempt 1	0.52	13.0
Basic	Standing	Attempt 2	0.52	13.0
Basic	Standing	Attempt 3	0.53	13.4
Basic	Standing	**Average**	**0.52**	**13.13**
Basic	Standing	**Best**	**0.53**	**13.4**
VKTRY	Standing	Attempt 1	0.52	13.0
VKTRY	Standing	Attempt 2	0.53	13.4
VKTRY	Standing	Attempt 3	0.51	12.6
VKTRY	Standing	**Average**	**0.52**	**13.00**
VKTRY	Standing	**Best**	**0.53**	**13.4**
Basic	Running	Attempt 1	0.57	15.7
Basic	Running	Attempt 2	0.61	17.7
Basic	Running	Attempt 3	0.58	16.1
Basic	Running	**Average**	**0.59**	**16.50**
Basic	Running	**Best**	**0.61**	**17.7**
VKTRY	Running	Attempt 1	0.60	17.3
VKTRY	Running	Attempt 2	0.58	16.1
VKTRY	Running	Attempt 3	0.58	16.1
VKTRY	Running	**Average**	**0.59**	**16.50**
VKTRY	Running	**Best**	**0.60**	**17.3**

Questionnaire Results

Category	Basic	VKTRY
Comfort	8.5	8.0
Stability/Support	8.0	8.5
Energy Return	7.0	7.5
Overall Performance	8.0	8.0

Preference/Recommendation: VKTRY; would recommend.

Additional Comments: None recorded.

Participant 9

Date: 09/25/2026

Insole Tested First: Basic

Vertical Jump Data

Insole	Jump Type	Trial	Flight Time (s)	Height (in)
Basic	Standing	Attempt 1	0.56	15.0
Basic	Standing	Attempt 2	0.56	15.0
Basic	Standing	Attempt 3	0.58	16.1
Basic	Standing	**Average**	**0.57**	**15.37**
Basic	Standing	**Best**	**0.58**	**16.1**
VKTRY	Standing	Attempt 1	0.58	16.5
VKTRY	Standing	Attempt 2	0.59	16.9
VKTRY	Standing	Attempt 3	0.58	16.1
VKTRY	Standing	**Average**	**0.58**	**16.50**
VKTRY	Standing	**Best**	**0.59**	**16.9**
Basic	Running	Attempt 1	0.61	17.7
Basic	Running	Attempt 2	0.60	17.3
Basic	Running	Attempt 3	0.61	17.7
Basic	Running	**Average**	**0.61**	**17.57**
Basic	Running	**Best**	**0.61**	**17.7**
VKTRY	Running	Attempt 1	0.62	18.5
VKTRY	Running	Attempt 2	0.61	18.1
VKTRY	Running	Attempt 3	0.61	17.7
VKTRY	Running	**Average**	**0.61**	**18.10**
VKTRY	Running	**Best**	**0.62**	**18.5**

Questionnaire Results

Category	Basic	VKTRY
Comfort	4.0	7.0
Stability/Support	4.0	7.5
Energy Return	5.0	8.0
Overall Performance	4.5	7.5

Preference/Recommendation: VKTRY; would recommend.
Additional Comments: None recorded.

Participant 10
Date: 09/28/2026
Insole Tested First: VKTRY
Vertical Jump Data

Insole	Jump Type	Trial	Flight Time (s)	Height (in)
Basic	Standing	Attempt 1	0.64	19.7
Basic	Standing	Attempt 2	0.63	18.9
Basic	Standing	Attempt 3	0.63	18.9
Basic	Standing	**Average**	**0.63**	**19.17**
Basic	Standing	**Best**	**0.64**	**19.7**
VKTRY	Standing	Attempt 1	0.64	19.7
VKTRY	Standing	Attempt 2	0.63	19.3
VKTRY	Standing	Attempt 3	0.63	19.3
VKTRY	Standing	**Average**	**0.63**	**19.43**
VKTRY	Standing	**Best**	**0.64**	**19.7**
Basic	Running	Attempt 1	0.65	20.1
Basic	Running	Attempt 2	0.66	20.9
Basic	Running	Attempt 3	0.65	20.1
Basic	Running	**Average**	**0.65**	**20.37**
Basic	Running	**Best**	**0.66**	**20.9**
VKTRY	Running	Attempt 1	0.65	20.5
VKTRY	Running	Attempt 2	0.66	20.9
VKTRY	Running	Attempt 3	0.66	20.9
VKTRY	Running	**Average**	**0.66**	**20.77**
VKTRY	Running	**Best**	**0.66**	**20.9**

Questionnaire Results

Category	Basic	VKTRY
Comfort	8.0	7.0
Stability/Support	7.0	9.0
Energy Return	7.0	10.0
Overall Performance	7.0	8.0

Preference/Recommendation: VKTRY; would recommend.
Additional Comments: None.