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*Retraction*

# Retracted: Effect of Running Pose Control Training on Ground Reaction Force, Lower Limb Kinetics

**Mobile Information Systems**

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

## References

[1] J. Zhang and M. Zhao, "Effect of Running Pose Control Training on Ground Reaction Force, Lower Limb Kinetics," *Mobile Information Systems*, vol. 2022, Article ID 5610892, 7 pages, 2022.

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*Research Article*

# Effect of Running Pose Control Training on Ground Reaction Force, Lower Limb Kinetics

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As a new strength training method, running form control training has been widely used in foreign athletes' strength training and public rehabilitation. As a means of auxiliary strength training, running form strength has attracted wide attention in China. In order to keep up with the latest international strength training theory and technology, the reaction force of people's running style on the ground was compared with the kinematics and dynamics of lower limbs and studied deeply. The significantly reduced load rate in the absence of running posture transformation is speculated to increase to the adaptation strategy of social body after changing shoe conditions. After training, the load rate was deep than that of the control group, increasing that even though the load rate could be reduced by the training method adapted to the ground hardness, the training effect with a clear goal was more significant. Through the comparison of lower limb joint kinematics and training effect, some flexor strength training methods can be added, and the load intensity and quantity can be appropriately increased, so that the proportion of the strength level of the extensor muscle of the lower limb joint can be coordinated, so as to better improve the coordination force level.



## 1. Introduction

As the most popular and common way of exercise, running has attracted more and more people's attention. However, the impact load of 2 to 3 times body mass per touchdown during running is considered to be a major risk factor for overuse injury. Therefore, how to reduce the impact force and the impact damage caused by running has always been a hot issue in related fields. At present, the effect of sneakers to reduce the impact of running is not obvious. Figure 1 shows the anatomy of running form training. Running injury rates have not changed significantly in the last 50 years despite advances in sneaker cushioning technology. In life, if you observe carefully, you will find that there are many people who run on the sole of their feet, and the sound of landing is relatively loud. In fact, the actual movement is in running, with the empty foot landing to the middle foot first. This is an ankle and knee protection to prevent periostitis. Arm swing is to maintain the balance and cohesion of the body during running, so that the swing of the body is more and more in line with the competition of human energy. When you swing your arms, just remember not to expose your elbow before and your hand after, and swing naturally with your feet. The AI team used traditional appearance analysis knowledge to conduct preliminary research on human motion, and found, found that wearing sneakers with strong cushioning function cannot effectively change the impact performance of human body when actively landing and muscle activation degree of lower limb muscle group. Therefore, researchers began to reexamine the issue in terms of lower limb posture control during running landing. Many factors can affect the occurrence of running injury, including internal factors such as human anatomy, injury history, biomechanics of lower limb movement, and neuromuscular control in movement and external factors such as training methods, running shoes, and running road surface. The running surface is considered to be one of the most important factors affecting running injuries. Regarding the effects of different soils on kinematics, dynamics, neuromuscular control, and low-speed sports injuries, it seems

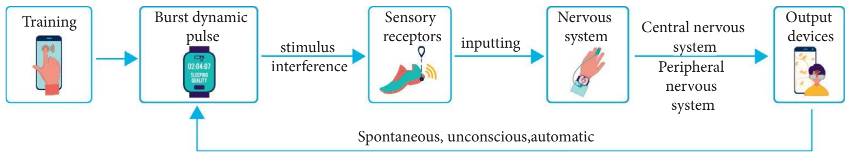


Figure 1: Analysis of the role of running form training. Exploring how to reduce the impact force during running and the resulting impact injury has always been a hot issue in related fields.

that when running at different speeds, the human body can adjust the kinematics through its own neuromuscular displacement function, accept mutations, and adjust the lower extremities to a similar degree impact. However, most studies on biomechanical changes of running on different road surfaces only focus on one aspect of kinematic dynamics and neuromuscular regulation. Further detailed 3D biomechanical data and specific neuromuscular regulatory mechanisms for such biomechanical adjustments are lacking.

## 2. Literature Review

Cveticanin said that the impact load of several times body mass per touchdown during running is considered a major risk factor for overuse injuries. Therefore, how to reduce the impact force and the impact damage caused by running has always been a hot issue in related fields [1]. Yu et al. put forward that, from an evolutionary point of view, many of the forms that modern humans possess (such as narrow pelvis and arches) evolved to adapt to bipedal running about 2 million years ago [2]. Kim and Duin put forward that the incidence of running injuries among runners is as high as 40% to 50% per year. Among running injuries, the knee joint is the most common site of injury, followed by ankle and foot. Repeated overloading may lead to acute injury (such as sprains, bone, and intra-knee disorders) or overwork injury such as stress fracture of the second metatarsal [3]. Millour et al. put forward that the kinematics research of different ground running mainly focuses on gait cycle, stride length, stride frequency, and hip, knee, and ankle joint angle characteristics [4]. Kang et al. held that, before the designed big data training, all subjects ran heel landing, and there was no significant difference in impact peak between different shoe conditions. However, wearing imitation bare foot shoes significantly increased the maximum load rate ($P < 0.05$) and decreased the time to reach the first and second peak values as well as the total touchdown time ($P < 0.05$) [5]. Cai et al. said that the effect of ground surface on running kinematic characteristics showed that the maximum flexion angle of knee joint remained unchanged under different hardness of ground. However, with the increase of the hardness of the ground, the hip joint flexion angle decreases, the maximum hip joint flexion angle decreases, and the peak value of hip joint closure angle increases [6]. Quak et al. said that wearing sneakers with strong cushioning function cannot effectively change the impact performance of the human body and the muscle activation degree of lower limb muscle groups when the human body actively lands [7]. Peracaula and Yu put forward that a large number of virtual machines must be properly placed on physical nodes and the constraints must be met. The static allocation methods include polling scheduling, minimum connection scheduling, first-adaptation, best-adaptation descending first-adaptation, descending optimal adaptive scheduling, destination address hash scheduling, and source address hash scheduling [8]. George and Mathew said that, from a very early time, the whole process of running landing force is the interaction and comprehensive effect of external forces such as ground reaction force and internal forces such as lower limb muscle force. Therefore, possible defects may exist in improving triceps muscle strength through training alone and hoping to adapt the Achilles tendon to the centrifugal load or radial load caused by running quickly and repeatedly [9]. Adarsh and Priya held that, when running on the hard low surface (such as sandy lawn), the hip and knee flexion angle and maximum flexion angle during the first touchdown stage and the middle support stage were greater than those on the hard surface (such as asphalt concrete). At the same time, running on a hard surface significantly reduced vertical acceleration compared to running on a hard surface, possibly reducing the risk of shin injury [10].

## 3. Research Method

*3.1. Building a Human Model.* A cautious attitude should be kept when using simulation method to get the impact force because the simulation method deduces the impact force through the method of building human body model and lacks the comparison with the actual situation. The data obtained in the laboratory can verify the accuracy of the input model data and the accuracy and validity of the model prediction results [11]. How similar the data obtained by simulation is to the actual data and to what extent it can represent the actual situation is a problem worth demonstrating. There are few researches on this aspect in China. In order to verify the accuracy and reliability of LifemMOD simulation method based on infrared light spot capture (motion) and 3D video shot by camera, the force curves obtained by simulation of vertical movement of steps at different heights are similar to those measured by force table [12]. Preliminary research found that wearing sneakers with strong cushioning function cannot effectively change the impact performance of human body when actively landing and muscle activation degree of lower limb, and the human body is in constant energy consumption and is easy to show fatigue, then if you can use your will to straighten your back, so you want to improve the humpback condition which is actually very simple. The effective mass of the lower limbs can be reduced by adjusting the angle of inclination at which the plantar makes contact with the ground (e.g., when the foreball touches the ground), thereby reducing the risk of impact injury. The study found a lower incidence of impact injuries when using the forepaw. In the follow-up study, barefoot or minimalist shoe training was used to achieve the forepaw touching the ground, so as to achieve the effect of reducing the risk of lower limb impact injury. It is worth thinking that bare foot is not the key to impact force, but the change of running posture brought by it is the main reason to affect impact force and lower limb biomechanics, which obviously needs to be established on the basis of long-term running posture change. For running on different surfaces, the variation of kinematic variables may not be significant due to the difference of individual running mechanisms, but there are observable changes [13]. Figure 2 shows the relationship between the force and the reaction force when running on the new rubber-modified asphalt surface and the moving surface of acrylic acid, and there is no significant difference in the kinematic variables on different surfaces, but there is an observable difference in the initial joint angle peak and angular velocity. The peak angle of ankle-knee joint increased when running on the new rubber-modified asphalt surface and acrylic surface, which was speculated to be related to the different mechanisms of individual runners' adaptation to different surfaces. In the future, further studies on large samples of different surfaces or stricter inclusion criteria for runners can be carried out to observe whether there are significant differences in kinematic variables of running on different surfaces. The LifeMOD interface software of Python language is used to convert Motion's 6 data and 2 kinematics data obtained from analysis and generate Slf files that LifeMOD can recognize. The height, weight, and other information of the subjects were input, and the 19-link human model was established through LifeMOD's own human morphology database. Figure 3 shows the posture adjustment after data is given. The collected kinematic data is given to the model, and then through posture adjustment and balance analysis, the floor pad model is established, and the contact between the human body model and the floor pad is established. The contact force between the human body model and the floor pad model, the force and moment of each link of the human body model, and the kinematic index of each link were simulated for 1s to obtain 1000 data, which was the same as the acquisition frequency of the force table [14]. Formula (1) of inertia for strength training is shown as follows:

$$j\theta + k\theta = T(t). \quad (1)$$

$j$ is the rotational inertia matrix and $T$ is the generalized torque vector.

All sports need the basic two but because of the different running posture, there is a need for basic strength for explosive training technical support [15]. And explosive force is the ability to generate maximum force in a short period of time, and formula (2) for force and speed is as follows:

$$p = F * V, \quad (2)$$

where $F$ represents force and $V$ represents speed.

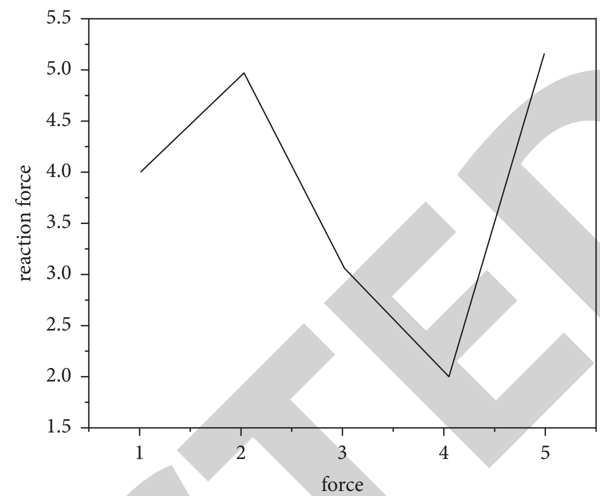


Figure 2: The relationship between action and reaction. Changes in kinematic variables may not be significant, but there are observable changes.

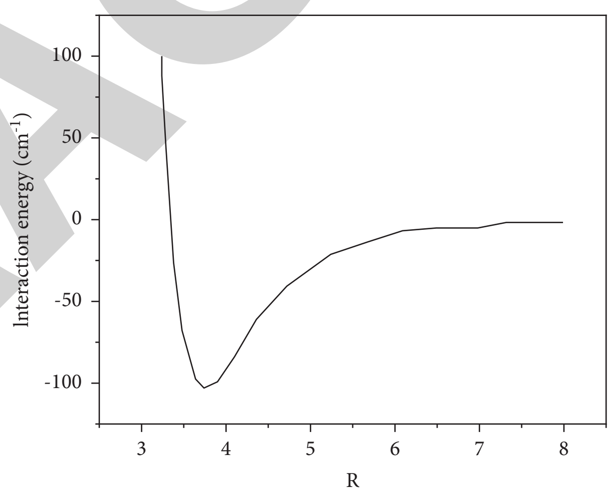


Figure 3: Pose adjustment after data is given. Through posture adjustment and balance analysis, establish a floor mat model.

In other words, explosive force is equal to big force plus fast speed. If it is inversely proportional, then the performance of explosive force cannot reach the optimal corresponding force formula (3) as

$$L = F^2 + N. \quad (3)$$

*3.2. Alteration of the Original Running Pose.* The subjects were asked to touch the ground with their forepaws while running at a moderate intensity optional speed while wearing minimalist shoes [16]. Subjects were informed of their approach to the ground by the acoustic feedback provided by wearing custom pressure insoles. The training was progressive three times a week for 12 weeks. The weekly running time was 5, 10, 15, 20, 25, 30, 35, 40, 42, 44, 46, and 48 min (in the last 4 weeks, in order to avoid exceeding the subjects' original exercise, the increase was slowed down). The intervention only replaced part of the amount of training, leaving the participants' original total weekly running distance unchanged. All subjects need to record training logs, and they need to wear the issued minimalist shoes and pressure sensing insole every time they run. The experimenters check with the training logs through cloud data. Inclusion criteria were as follows: all as required. No more than 3 times of intermittent training are required, and all completed the last 3 weeks of training as required. Run with a steady head and shoulders. Look straight ahead, chin slightly in but not down. When running, the shoulders are relaxed and drooped first, then as far as possible up, stay for a while, restore the original position, and repeat. Hold the hands slightly, bend the arms to about 90 degrees, and swing back and forth naturally. Pay attention to keeping the elbows on the front arm and your hands on the back arm. During training, shoe conditions have an effect on biomechanics of running before and after training, but the effect is similar, mainly in the condition of imitation bare foot shoes, the foot contact angle decreased, and the joint and power increased [17]. Figure 4 is the characteristic diagram of reaction force. This suggests that running in a faux barefoot shoe produces more thrust and can improve performance. The study found that the increased cross-sectional area and stiffness of the Achilles tendon in forepaw runners increased the running economy and reduced the risk of injury during long distance running compared to heel runners. The study found that, after 12 weeks of training, heel runners were more likely to run on the forefoot and exhibit a similar kinematic pattern to barefoot running. The results of the study found that six weeks of form conversion training may change the movement pattern of habitual heel landing runners. But what kind of mechanical influence does this kind of running form transformation training have on the Achilles tendon? Figure 5 is shown below and the normal ground force is shown in formula (4):

$$F = F_{Ya} + F_{YY}. \tag{4}$$

The reaction force is the upward reaction from the ground to the lower limbs to propel the body forward and from the lower part of the body to the feet [18]. And the formula for the reaction is as follows:

$$F' = -F. \tag{5}$$

For example, when objects collide, their speed and force will change accordingly. The formula is as follows:

$$Ft = mv' - mv. \tag{6}$$

$F$ is the force of the collision, $t$ is the time of the collision, $v$ is the initial velocity of the object being touched, $v'$ is the velocity of the object being touched.

*3.3. Adjust the Hardness of the Ground.* The study found that all plantar variables and pressure areas were similar when running on asphalt and concrete surfaces. When running on natural grass, there is more contact time and surface area in

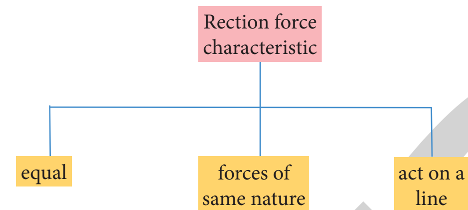


Figure 4: Reaction force characteristic. Decreased foot contact angle and increased stomping knuckle and power under simulated barefoot conditions.

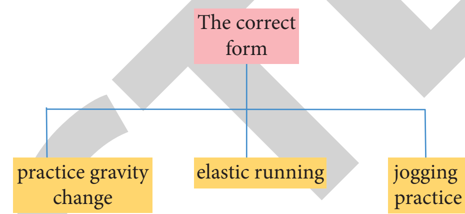


Figure 5: Correct running style training features. Heel runners are more likely to use the forefoot stance, while exhibiting a kinematic pattern similar to barefoot running.

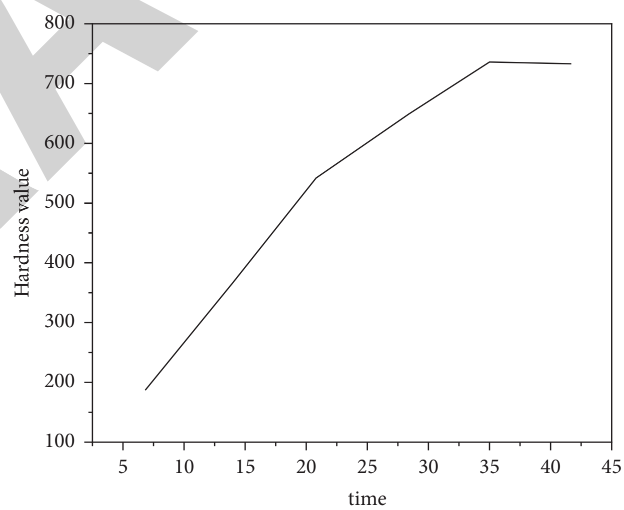


Figure 6: Surface hardness number. The musculoskeletal system may experience lighter loads when running on low-hardness surfaces.

the back and forefoot areas. Running on asphalt leads to greater load in the lateral area of the back foot. But when running on natural grass, the pressure peak was significantly lower than on other surfaces [19]. Therefore, if runners control the amount and intensity of exercise, compared to the hard ground, running on low-hardness surfaces (natural grass) may place a lighter load on the musculoskeletal system, possibly reducing the risk of injury. The surface hardness is shown in Figure 6. By analyzing the plantar pressure data of running on standard plastic track and indoor treadmill with buffering performance and without buffering performance, the results were found. In the process of landing, there was no significant difference in the distribution of the maximum plantar pressure peak (and occurrence time) on the three different running surfaces of the cement track without buffer (without buffer). When you are running, you can choose to use the thigh to drive the calf, and the knee joint must be towards the toe direction, lift to a reasonable height and then put down, and repeat. Preliminary research found that wearing sneakers with strong cushioning function cannot effectively change the impact performance of human body when actively landing and muscle activation degree of lower limb. Compared with other surfaces, both grass and buffering treadmill (with buffering) reduced part of the peak pressure at touchdown, but there was no significant difference in the distribution of maximum pressure. At the same time, there was no significant difference in tibial acceleration on all surfaces. Firstly, through the comparative analysis of walking on the ground and on the treadmill, it is found that the dynamics parameters of the two conditions are basically similar, and the differences are also within the range of repeatability. Therefore, it is considered that the dynamics of walking on the treadmill and on the ground are very similar [20]. Then, by comparing the dynamic parameters of running on the treadmill and on the ground, it was found that the peak propulsive force on the treadmill and the ground reaction force inside the peak decreased significantly. The surfaces were further divided into concrete and grass and compared to running on a treadmill. It was found that running on a treadmill had less maximum plantar pressure than running on concrete or grass, mainly in the inner forefoot, big toe, and little toe areas. Compared with ground running, treadmill running increases the time the foot is in contact with the ground, alters the plantar pressure distribution, and reduces peak pressure, especially in the inner heel metatarsal and big toe areas. See Figure 7. As a result, there is a significant difference in plantar pressure between the treadmill and the ground, and the treadmill has a smaller pressure peak. Running on a treadmill can be used as an early training method to provide lower plantar load for people with lower limb injuries. The hardness of the ground can also be calculated by the Richter hardness:

$$HL = 1000 * \frac{VB}{VA}. \tag{7}$$

In addition, it can also be calculated by shore hardness:

$$HS = HRC + 15. \tag{8}$$

## 4. Result and Analysis

The impact development is thought to be the main cause of deep limb overuse injury. The effective mass can be reduced by adjusting the angle between the job and the project when the forepaw touches the ground, so as to avoid the high impact caused by the heel touching the ground [21]. In addition, load rate, which is a very sensitive indicator of impact force when running to the ground, decreased significantly after training in both groups in the study. It is

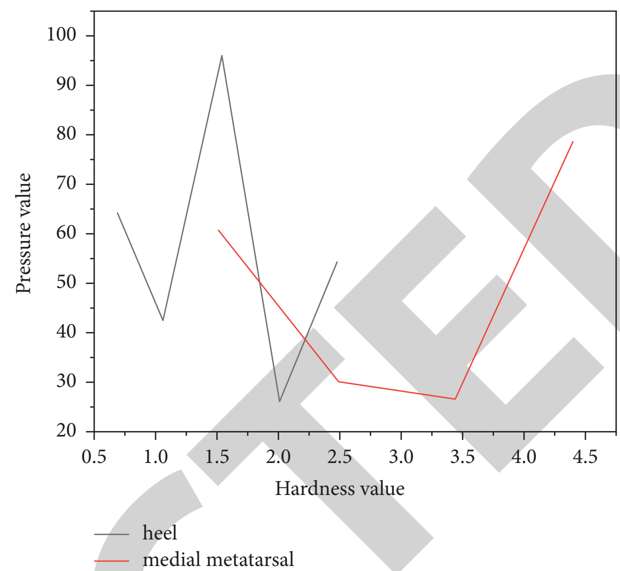


Figure 7: Ground hardness against the metatarsal pressure on the inside of the heel. Changing plantar pressure distribution while reducing peak pressure, especially in the heel, medial metatarsal, and big toe areas.

speculated that the reason is that the first peak impact force is avoided, and the load rate is reduced by the change of touchdown mode after the change of running form, which is the same as the results of other communication projects. Preliminary research found that wearing sneakers with strong cushioning function cannot effectively change the impact performance of human body when actively landing and muscle activation degree of lower limb. Running consistently will give you a strong heart and cardiovascular system. When the maximum oxygen uptake is increased, the amount of oxygen delivered to various organs of the body is greatly increased, and the work quality of each organ is naturally greatly improved. In addition, long-distance running will accelerate blood circulation, so that the coronary arteries have sufficient blood supply to the heart muscle, thereby preventing various heart diseases. Through the movement of the lower limbs, it promotes venous blood flow back to the heart and also prevents venous thrombosis. With a strong cardiovascular system, the blood quality of runners is better than that of ordinary people, and the body's adaptive changes to long-term long-distance running can improve metabolism and reduce blood lipid and cholesterol levels. However, the load rate of the control group was significantly reduced without running posture transformation, which was speculated to be related to the adaptation strategy of human body after changing shoe conditions. After training, the load rate was lower than that of the control group, indicating that even if the training method being adapted to shoe conditions can reduce the load rate, the training effect with a clear goal is more significant, suggesting that minimalist shoes can better reduce the load rate and avoid the peak impact force. From the perspective of neuromechanics, the human neuromuscular system can respond to changes in the external environment. Use signal

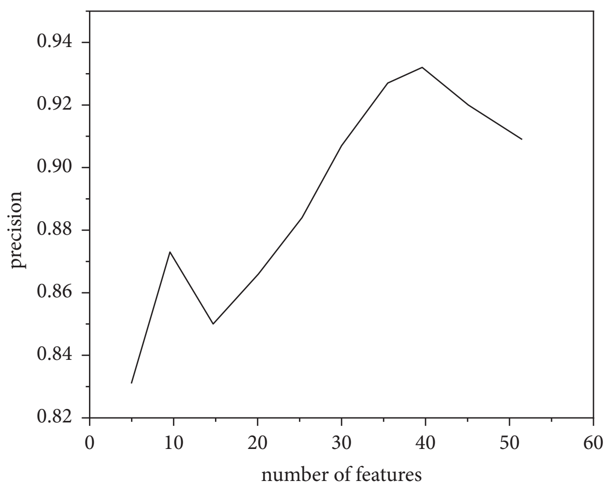


Figure 8: Changing the ground accuracy effects. Preactivation of the peripheral neuromuscular system to perform appropriate actions according to different environments.

feedback mechanism to balance the input and output signals to adapt to the changing external environment. See Figure 8. At the same time, the central nervous system of the human body will carry out feedforward adjustment to the changes in the external environment and preactivate the peripheral neuromuscular system to perform appropriate actions according to the different environment. On different surfaces, runners adjust their lower limb stiffness in time through neuromuscular control, which allows runners to maintain similar centroid motion (i.e., maintain the same ground contact time and stride frequency) while running, regardless of ground hardness. Shifting from hard to soft ground, lower leg stiffness increases by adjusting leg stiffness to match ground stiffness to maintain similar motion mechanics. At the same time, on different surfaces, the body quickly adjusts its leg position on the first step of the new surface to maintain the same center of gravity. The study on the changes of kinematics and mechanics of human lower limbs and the change rules of human neuromuscular control mechanism during running will help to explain why the mechanical changes of lower limbs occur during running.

## 5. Conclusion

In modern society, running, as the most popular and common way of mass fitness and competitive sports, has attracted more and more people's attention. However, the impact load of 2-3 times body weight per landing is considered to be the main risk factor for overuse injuries such as stress fracture/fracture, femoral joint pain syndrome, plantar fasciitis, and injuries. This study investigated the relationship between running posture, landing impact, and lower extremity biomechanics by comparing the changes of landing impact and the kinematics and dynamics of the lower extremity hip, knee, and ankle before and after 12-week running posture control training with forefoot touching the ground. Running form control training has a significant effect on the biomechanical properties of Achilles tendon, and the Achilles tendon strength is significantly higher during running after training, which enables the Achilles tendon to complete energy storage and release more effectively during running. The increased mechanical properties of Achilles tendons and the decreased RMS amplitude of EMG indicated that the muscle activation was lower but more efficient at the same running speed, suggesting that running form control training can positively improve the Achilles tendons' ability to withstand loads, thus preventing and reducing the risk of injury. Running is the best exercise anyone can do to raise cholesterol, reduce the risk of blood clots, and exercise the 50 percent of your lungs that often sit idle. Correct running form can also boost your immune system by boosting your lymphocytes. In addition, for runners who are accustomed to heel contact, it is recommended to adopt a gradual way of running form transformation training and try to coordinate with the strengthening exercise of lower limb muscle groups. A successful exercise intervention model was established by using the heel landing mode combined with the wearing of minimalist shoes, and the runners who originally landed on the heel were converted to the heel landing mode (conversion rate was 78%). Just as good running form is good for your body, so is good running form for your mind. By overcoming a series of obstacles while running, you learn focus and determination. After a long run or any other event that you almost gave up on, you will find that the mental and physical strength you develop while running gives you the same focus and determination you have in other areas. The specific performance is as follows. ① The impact peak can be more effectively avoided to reduce the maximum load rate, thus reducing the risk of running injuries caused by impact. ② The stiffness of lower limbs was significantly improved, suggesting that it was possible to improve running economy and corresponding energy utilization rate. ③ The stronger purpose makes the training effect (i.e., the efficiency of running form change) higher. After summarizing the causes of running injury, it was found that the main causes supported by epidemiology were weekly running miles, previous running injury history, faster running speed, and less running experience. The strongest factor affecting running injury was mileage per week, and the relationship between running surface and running injury was not mentioned. Research limitations of this paper are as follows. Due to the long training time and the difficulty of later training, the subjects lost more due to personal reasons, resulting in a small sample size. Although the training of subjects is monitored by cloud data, at the same time, the log records are used for investigation. However, each person's learning ability of actions will lead to different training effects. It is not possible to provide timely feedback through cloud monitoring. In addition, surface electromyography should be included in future research to analyze more deeply how the running posture of runners changes during training and under different shoe conditions.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The authors declare no conflicts of interest.

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