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Biomechanical Analysis of Lower Limbs Based on Unstable Condition Sports Footwear: A Systematic Review

REVIEW

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ABSTRACT

The purpose of this paper is to summarize the functional arguments for unstable footwear in the recent research literature and to explore the different effects of various unstable designs of footwear in enhancing muscle strength training, improving stability and loss prevention. According to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) criteria, to find all the relevant studies for this systematic review, a comprehensive electronic search was conducted. The following keyword combinations were used as part of a standardized electronic literature search strategy: 'unstable OR bionic OR MBT' AND 'shoe OR shoes OR footwear' AND 'biomechanics OR kinetics OR kinematics OR muscle force' from 2000 until November 2021 using the following databases: ScienceDirect, Web of Science and PubMed online. There were 17 articles included in this review, eight consisting of anterior-posterior (AP) unstable condition studies and nine consisting of medial-lateral (ML) unstable condition studies. It was also uncovered that AP unstable footwear is more suitable for fully developed adults, while for ML unstable footwear is perhaps more suitable for children and adolescents.

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INTRODUCTION

The shoes that people wear every day are mainly dedicated to maintaining and improving the stability and postural control of the human body, especially the foot, during sports (Reinschmidt and Nigg, 2000). With the continuous development and evolution of footwear research and development, the 1970s saw the creation of sports shoes with different purposes such as improving sports performance and reducing sports injuries (Zhou et al., 2024). The demand for footwear gradually evolved from traditional functions such as foot protection and shock absorption to different sports needs in order to play a diversified role. Modern companies and markets are focusing their design concepts on shock absorption, motion control, regulation of plantar pressure distribution and traction performance (Goff et al, 2018) in response to consumer demand, with the aim of creating training equipment that improves performance while reducing the risk of injury (Nigg and Enders, 2013). Unstable shoes are a type of functional footwear. It relies on the training concept of trunk stability in competitive sports and changes the structural design of the sole such that it has a different kind of unstable interface to traditional sports shoes. The change in the sole structure first causes the foot to feel the "instability" of the contact interface during movement, which is then transmitted through the kinetic chain to the lower limbs and the entire torso, forcing the body to constantly adjust its posture during movement, and while the movement pattern changes, the muscles and joints, which are the power carriers, also adjust in parallel, increasing the control by increasing muscle (Zhou et al., 2021b; Gu et al., 2014). The change in movement pattern often triggered by increasing muscle activation is accompanied by a simultaneous adjustment of the muscles and joints, which are the power carriers designed to improve control and maintain body balance without falling (Nigg et al., 2009; Stöggl et al., 2010; Waddington and Adams, 2004).

The importance of the unstable structure of the shoe is that it improves the sensitivity and responsiveness of the trunk to balance, exercises the trunk's kinesthetic senses in small directional controls, and makes kinesthetic exercises more concise and effective, hence the significant increase in information about the ability of unstable shoes to promote human health in recent years. The rounded sole design of unstable structured shoes, particularly ML unstable structured shoes, allows for the unstable internal and external oscillation of the foot during exercise, which can simulate a test of dynamic balance, provide appropriate stimulation of the motor senses, and enhance the body's adaptation to unstable situations for improved postural control (Turbanski et al., 2011; Lohrer et al., 2008). During exercise in unstable structured shoes, the muscles and proprioception are systematically trained to produce beneficial functional effects on both the small muscle groups of the foot and the musculature of the lower limbs. In particular, for muscle fibers with slow contraction properties, the ability of the muscles around the joints to do work is improved, and muscle stability is promoted to enhance trunk balance. A great deal of previous research on unstable functional shoes has focused on two types of shoes, namely the Masai Barefoot Technology (MBT) unstable shoes in the AP direction and unstable shoes in the ML direction (Figure 1). In other words, by adding local instability elements to the sole or changing the structural design of particular parts of the sole to induce changes in systemic instability, this results in significant changes in lower limb joint kinematics, the degree of lower limb muscle activation, and the distribution of plantar pressure, thus enabling enhanced training effects and achieving therapeutic effects of improving balance or relieving

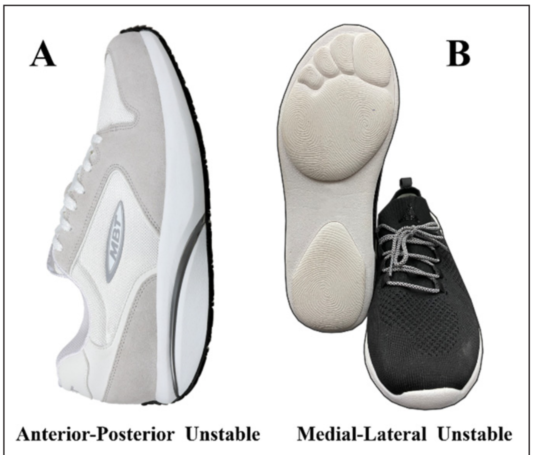

Figure 1 A. Anterior-posterior unstable condition shoes; **B.** Medial-lateral unstable condition shoes.

load in specific areas (Nigg et al., 2006; Stöggl et al., 2010; Li et al., 2015; Nigg, 2009; Nigg et al., 2012; Mei et al., 2015).

The stability and support provided by traditional sports shoes are adequate for the protection of the foot, but potentially could cause a decline in the function and strength of the small muscle groups of the foot compared to their initial human state (Stewart et al., 2007; Hsi et al., 2004; Nigg et al., 2006; Wallden, 2010). With this in mind, research has tended to focus on unstable footwear as footwear with fitness functions, improved balance and even enhanced muscle activation, bringing it into the public eye and at the same time developing it rapidly. Inspired by the idea of training for trunk stability in competitive sport, the unstable structure of the sole changes from a flat initial state to an unstable protruding interface, so that the body is in a constant state of 'instability' when in contact with the ground. The curved shape of the sole as an unstable structure stimulates the kinesthetic system and improves the body's ability to control posture and gait, which in turn enhances muscle activity and improves proprioception, muscle strength and coordination. It has an effect on the small muscle groups of the foot and the overall musculature of the lower limb, particularly on the slow-contracting muscle fibers. The strengthening of the muscles also means that the protection of the corresponding joints is also improved, maintaining joint stability and enhancing balance (Zhou et al., 2021b).

The purpose of this paper was to summarize the functional arguments for unstable footwear in the recent research literature and to explore the different effects of various unstable designs of footwear in enhancing muscle strength training, improving stability and prevention of injuries. For people who have been wearing stabilizing footwear for a long time, it provides an effective way to change their exercise habits. Emphasis would be channeled towards finding out how different unstable footwear can address the needs of different populations.

METHODS

SEARCH STRATEGY

In accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) criteria (Moher et al., 2010; Page et al., 2021; Moher et al., 2015), a comprehensive electronic search was conducted to find all the relevant studies associated with this systematic review. The following keyword combinations were used as part of a standardized electronic literature search strategy: 'unstable OR bionic OR MBT' AND 'shoe OR shoes OR footwear' AND 'biomechanics OR kinetics OR kinematics OR muscle force' from 2000 until November 2021 using the following databases: ScienceDirect, Web of Science and PubMed online. Older articles may not be as relevant as shoe alterations that are unlikely to be accessible in the present market, given the rapid improvement in material science and design in the shoe business, as shown by new ideas and technologies every season. It was thus necessary to limit the search to publications published after 2000 to guarantee relevance and context.

ELIGIBILITY CRITERIA

Images depicting this procedure are shown in Figure 2. Using Excel, all articles were entered into the database to remove any duplications. We then included genuine studies published in peer-reviewed publications that examined the effects of shoe modifications with an unstable structure on biomechanical alterations (such as muscle force, plantar pressure, kinetics, and kinematics). For this review, we looked only at studies that reported on the impact on biomechanical parameters of participants of any age, gender, mass, or performance level by reporting absolute data (means and measures of variability).

The following criteria were used to exclude articles: (1) Conference abstracts, review articles; (2) Investigation of high-heel shoes; (3) Barefoot shoes.

DATA EXTRACTION AND QUALITY ASSESSMENT

This review study covered all full-length research publications. The quality of the included studies was assessed using a modified Quality Index Checklist (Downs and Black, 1998). The maximum score for each article in this review was 15, and two independent researchers rated each study. When two researchers could not agree on any of the items, a conference call was held to get

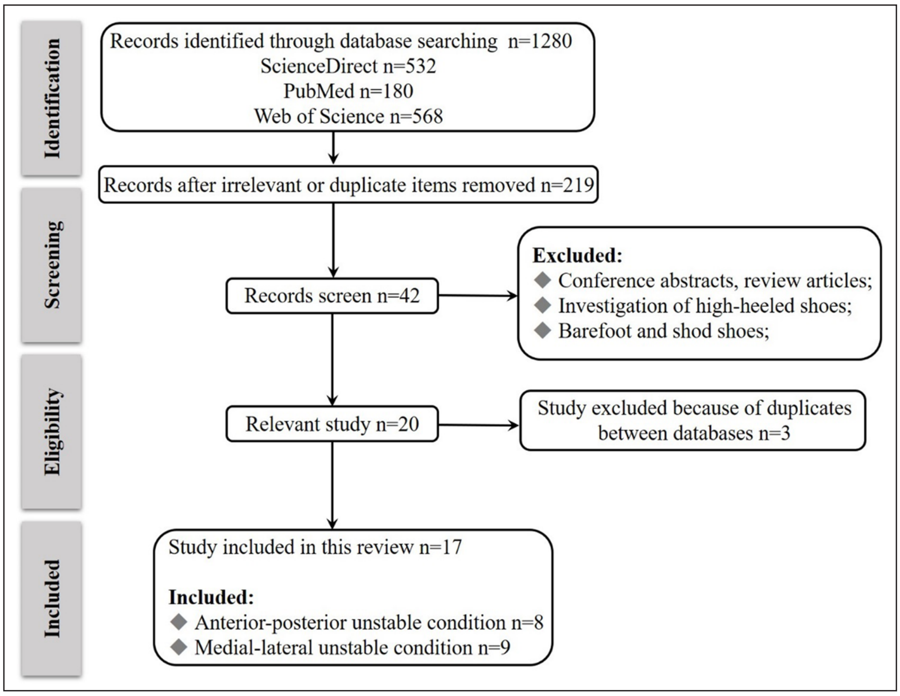

Figure 2 PRISMA flow diagram description of the review search process.

a final judgment. There were times when a third researcher was brought into the debate to help resolve any differences of opinion. When a study satisfied the inclusion requirements and scored more than 50% on the checklist, it was considered for inclusion in this review (Simpson et al., 2019). Citations and bibliographies were organized using Mendeley software (Amsterdam, Netherlands). The specific information and score are shown in Tables 1 and 2.

Table 1 Specific questions and rank of Quality Index checklist.

NUMBER	RANK OF QUALITY INDEX CHECKLIST (SCORES)	SPECIFIC QUESTIONS
1	1(1 or 0)	Is the hypothesis/aim/objective of the study clearly described?
2	2(1 or 0)	Are the main outcomes to be measured clearly described in the Introduction or Methods section?
3	3(1 or 0)	Are the characteristics of the patients included in the study clearly described?
4	5(2 or 1 or 0)	Are the distributions of principal confounders in each group of subjects to be compared clearly described?
5	6(1 or 0)	Are the main findings of the study clearly described?
6	7(1 or 0)	Does the study provide estimates of the random variability in the data for the main outcomes?
7	10(1 or 0)	Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?
8	11(1 or 0)	Were the subjects asked to participate in the study representative of the entire population from which they were recruited?
9	12(1 or 0)	Were those subjects who were prepared to participate representative of the entire population from which they were recruited?
10	16(1 or 0)	If any of the results of the study were based on data dredging, was this made clear?
11	18(1 or 0)	Were the statistical tests used to assess the main outcomes appropriate?
12	20(1 or 0)	Were the main outcome measures used accurate (valid and reliable)?
13	21(1 or 0)	Were the patients in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited from the same population?
14	22(1 or 0)	Were study subjects in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited over the same period of time?

AUTHORS	YEAR	1	2	3	5	6	7	10	11	12	16	18	20	21	22	TOTAL (15)	PERCENTAGE (%)
Zhou et al.	2021(a)	1	1	1	0	1	1	1	0	0	1	1	1	1	1	12	80
Xu et al.	2021	1	1	1	0	1	1	1	0	0	1	1	1	1	1	12	80
Zhou et al.	2021(b)	1	1	1	0	1	1	1	0	0	1	1	1	1	1	12	80
Gu et al.	2014	1	1	1	2	1	1	1	0	0	1	1	1	1	1	13	87
Li et al.	2015	1	1	1	2	1	1	1	0	0	1	1	1	1	1	13	87
Mei et al.	2015	1	1	1	1	1	1	1	0	0	1	1	1	1	1	12	80
Jiang et al.	2021(a)	1	1	1	0	1	1	1	0	0	1	1	1	1	1	12	80
Jiang et al.	2021(b)	1	1	1	0	1	1	1	0	0	1	1	1	1	1	11	73
Zhou et al.	2018	1	1	1	2	1	1	1	0	0	1	1	1	1	1	13	87
Zhang et al.	2012	1	1	1	1	1	1	1	0	0	1	1	1	1	1	12	80
Lee et al.	2019	1	1	1	1	1	1	1	0	0	1	1	1	1	1	12	80
Pyo et al.	2008	1	1	1	1	1	1	0	0	0	1	1	1	1	1	11	73
Nigg et al.	2006	1	1	1	2	1	1	0	0	0	1	1	1	0	1	11	73
Branthwaite et al.	2013	1	1	1	1	1	1	1	0	0	1	1	1	0	1	11	73
Nigg et al.	2010	1	1	1	2	1	1	1	0	0	1	1	1	0	1	13	87
Sousa et al.	2014	1	1	1	1	1	1	1	0	0	1	1	1	1	1	12	80
Landry et al.	2010	1	1	1	1	1	1	1	0	0	1	1	1	0	1	11	73

Table 2 Results of the quality assessment based on the modified Quality Index checklist.

For the papers reviewed, the Modified Quality Index Checklist averaged 79.58%, with a range of 73% to 87%. The two researchers were found to be 96% in agreement. Disagreements were resolved and various scores were re-rated throughout the conversation, resulting in a final agreement between researchers of 100 percent. The Modified Quality Index Checklist findings revealed that question 21 and 22 of the ranked were the main methodological constraints of the included papers.

RESULTS

As depicted in Figure 1, the first search generated a total of 1280 possible publications from ScienceDirect, PubMed, and Web of Science databases. After deleting all the irrelevant or duplicates, 219 records were maintained for screening the title and abstract. Based on the inclusion criteria and exclusion criteria, 42 articles were excluded following the screening. Therefore, 20 records received the full-text examination. Three papers were removed following the full-text examination. There were 17 articles included in this review, 8 consisting of AP unstable condition studies and 9 comprising of ML unstable condition studies.

Table 3 shows that there are 9 of ML unstable condition studies: two of the studies investigated kinetic and kinematic changes of lower limbs during drop landing tests (Xu et al., 2021; Zhou et al., 2021a); three of the studies investigate plantar pressure during walking tests (Li et al., 2015; Mei et al., 2015); one study investigates kinematics and muscle force during a walking test (Gu et al., 2014); two of the studies investigated before and after prolonged running tests (Jiang et al., 2021a; Jiang et al., 2021b); and one study investigated joint angle during walking and jogging tests (Zhou et al., 2018); and one study investigated kinetics, kinematics and muscle forces during walking and running tests (Zhou et al., 2021b).

Table 4 shows that there are 8 AP unstable condition studies: four of the studies investigate walking tests where Pyo and Branthwaite focused on muscle force changes (Pyo et al., 2008; Branthwaite et al., 2013), Zhang focus on kinetics, kinematics and muscle force (Zhang et al., 2012), Lee focused on kinetics and kinematics (Lee and Chae, 2019); two studies investigated walking and standing test, one focused on kinetics, kinematics and muscle force (Nigg et al., 2006), one study focused on kinetics and kinematics (Nigg et al., 2010); two of the studies investigated the changes of muscle force and center of pressure during standing tests (Sousa et al., 2014; Landry et al., 2010).

Table 3 Summary of the included studies related to medial-lateral unstable condition.

AUTHOR(S)	TYPE OF UNSTABLE SHOES	PARTICIPANTS	TESTING PROTOCOL	JOINT	OUTCOME			MAIN FINDINGS
					KINEMATICS	KINETICS	MUSCLES	
Gu et al., 2014	Unstable structure shoes	22 males	Walking on a 10m walkway	Ankle, knee and hip	Walking speed, cadence, stride length, foot-off time, stride time and angle	/	Tibialis anterior, peroneus longus, medial and lateral gastrocnemius, vastus medialis, rectus femoris, vastus lateralis and biceps femoris	Unstable training equipment could improve postural control by altering lower leg kinematics and rearranging muscle activation.
Li et al., 2015	Unstable shoe	16 females	Walking	Knee	/	Moment and plantar pressure distribution	/	Plantar pressure moved from the medial foot to the lateral foot while wearing soft unstable shoes, as opposed to hard unstable shoes.
Mei et al., 2015	Unstable shoe	22 males	Walking over a 12m walkway	/	Contact area	Plantar pressure and pressure-time integral value	/	The location of the unstable element might be easily modified to satisfy varied functional needs.
Zhou et al., 2018	Bionic shoes	10 males	Walking and jogging	Ankle, knee and hip	Angle	/	/	The results of the research show that people prefer the hard bionic shoes over the softer soles when exercising.
Jiang et al., 2021b	Bionic shoes	16 males	Before and after 5km running	/	/	Ground reaction force	/	Running with bionic shoes may reduce the chance of injury.
Jiang et al., 2021a	Bionic shoes	16 males	Before and after 5km running	Ankle, knee and hip	Angle and range of motion	Moment	/	Wearing bionic shoes might help strengthen muscles and improve postural stability as well as proprioception.
Xu et al., 2021	Bionic shoes	15 males	Single-leg landing from 35cm platform	Ankle, knee and hip	Angle and range of motion	Power, moment, joint force and energy distribution	/	Bionic footwear alters the lower limb kinematics at first contact and then adjusts the landing strategy for joint work and joint response force, minimizing the risk of lower limb skeletal muscle damage.
Zhou et al., 2021b	Bionic shoes	15 males	Walking and running on a 10m walkway	Ankle, knee and hip	Angle	Moment	Medial and lateral gastrocnemius, vastus medialis, vastus lateralis, rectus femoris, and tibialis anterior	Stability in the lower limb muscles and rehabilitation exercise may be more beneficial with this kind of shoe than other footwears.
Zhou et al., 2021a	Bionic shoes	15 males	Single-leg landing from 40cm platform	Ankle, knee and hip	Angle and range of motion	Moment and ground reaction force	/	During the single-leg landing phase, bionic shoes may produce more knee and hip flexion than conventional shoes.

Table 4 Summary of the included studies related to anterior-posterior unstable condition.

AUTHOR(S)	TYPE OF UNSTABLE SHOES	PARTICIPANTS	TESTING PROTOCOL	JOINT	OUTCOME			MAIN FINDINGS
					KINEMATICS	KINETICS	MUSCLES	
Nigg et al., 2006	MBT shoes	5 males and 3 females	Walking and standing	Ankle, knee and hip	Angle	Moment, ground reaction force, angular impulse and center of pressure	Tibialis anterior, gastrocnemius, vastus medialis, biceps femoris and gluteus medius	The locomotor system seemed to benefit from changes and trends in kinematic, kinetic, and electromyographic features caused by the MBT shoe.
Pyo et al., 2008	MBT shoes	6 males	Walking	/	/	/	Medial and lateral gastrocnemius, soleus, tibialis posterior, flexor digitorum longus, flexor hallucis longus, pectineus, rectus femoris, biceps femoris long head, biceps femoris short head, vastus intermedius, vastus medialis and vastus laterialis	MBT shoes with rounded bottoms activate lower extremity muscles by interrupting the stability of the body; the degree of improvement in this regard is around 7.44 percent.
Landry et al., 2010	MBT shoes	9 males and 19 females	Standing	/	/	Center of pressure	Flexor digitorum longus, soleus, peroneus group and anterior compartment group	Standing in an unstable MBT shoe engages certain extrinsic foot muscles, which might have consequences for strengthening and training these muscles.
Nigg et al., 2010	MBT shoes	17 males and 17 females	Standing and walking on a 30m walkway	Ankle, knee and hip	Angle	Moment, center of pressure and moment impulses	/	Female individuals demonstrated a substantially higher anterior-posterior center of pressure excursion than male subjects in bipedal posture.
Branthwaite et al., 2013	MBT shoes	12 males and 8 females	Walking over a 10m walkway	/	/	/	Tibialis anterior, peroneus longus, medial gastrocnemius, lateral gastrocnemius, soleus, rectus femoris, biceps femoris and gluteus medius	The use of MBT shoes does not have a universally good effect on muscular behavior, and the time point at which this might occur is unpredictable.
Zhang et al., 2012	MBT shoes	15 males	Walking at 1.3m/s and 1.8m/s	Ankle, knee and hip	Angle and range of motion	Moment and center of pressure	Tibialis anterior and rectus femoris	To maintain mediolateral stability, the foot is challenged by the rocker shoes, which aids in strengthening the muscles of the hips and ankles that are directly engaged.
Sousa et al., 2014	MBT shoes	30 females	Standing	/	/	Center of pressure	Gastrocnemius medialis, tibialis anterior, rectus femoris and biceps femoris	Increased ankle and muscle group antagonist co-activation levels and improved postural control system performance may be attributed to the long-term usage of MBT shoes
Lee et al., 2019	MBT shoes	A 29-year-old man	Walking	Ankle and knee	Angle	Ground reaction force and contact pressure of joint	/	The maximal pressure exerted on knee and ankle cartilages during a walking cycle was reduced by the MBT shoes.

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DISCUSSION

The purpose of this paper is to summarize the functional arguments for unstable footwear in the recent research literature and to explore the different effects of various unstable designs of footwear in enhancing muscle strength training, improving stability and prevention of injuries. For people who have been wearing stabilizing footwear for a long time, it provides an effective way to change their exercise habits. Emphasis would be channeled towards finding out how different unstable footwear can address the needs of different populations. Based on the results, AP and ML direction are both unstable shoes, but they have distinct functions and relevance.

The proposed definition of instability is derived from the relationship between the position of the human center of gravity and the part of the foot in contact with the ground. During movement, the trajectory of the body's center of gravity does not exceed the vertical range of the trajectory of the center of pressure, either in the AP or ML direction of the path of travel. If it does, the body's posture and movement pattern will change accordingly, which in turn will cause a change in gait, resulting in the body being unable to maintain balance and stability, thus making it easy to fall. A great deal of research has been conducted on functional instability footwear, including MBT instability footwear in the AP direction, and instability footwear in the ML direction, where the addition of local instability elements to the sole or changes in the design of specific areas of the sole can cause systemic instability stimuli, resulting in significant changes in lower limb kinematics, lower limb muscle activation and pressure distribution on the bottom of the foot, leading to training effects that enhance balance or relieve load in specific areas. The structure and design of this range of footwear varies in detail, but all aim to increase muscle strength in the foot or lower limb, improve postural control and have a beneficial effect on physical health.

According to studies from kinematics of MBT shoes (Zhang et al., 2012; Lee and Chae, 2019; Nigg et al., 2006; Nigg et al., 2010), the results in this paper demonstrate that the sagittal plane joint angle or range of motion during walking is significantly greater with MBT shoes than with regular footwear, for both ankle and knee joints and hip joints. This explains that, in terms of joint angle and range of motion, the rounded shape of the MBT sole in the AP direction forces the user to change the joint angle when walking forward. On the one hand, the increased joint angle allows the joints of the lower limbs to be better cushioned (Griffin et al., 2000), thus reducing the impact on the joints. Conversely, from a kinesiology point of view, this kind of MBT shoes can be applied to the scene or the crowd is limited, not every person or crowd is suitable. The most significant changes in the kinematics of the lower limbs when walking and running come from the frontal plane (Li et al., 2015; Gu et al., 2014; Jiang et al., 2021a; Zhou et al., 2018; Zhou et al., 2021b), which shows that this kind of ML unstable footwear or bionic shoes is more suitable for the majority of people. By realistically restoring the instability when barefoot, to achieve the role of improving the stability of the lower function. It is worth mentioning that in the single-leg landing test, some researchers found that the use of bionic shoes can effectively increase the knee and hip flexion angle, so that the cushioning mechanism in the landing is more perfect. In this regard, Xu and Zhou explained that this is likely because the organism has sensed the instability during the preparation phase, thus having a pre-activation-like situation (Zhou et al., 2021a; Xu et al., 2021). This is actually further evidence that ML unstable footwear also changes the kinematic data on the sagittal plane to some extent.

From a lower limb joint dynamics point of view, both AP unstable MBT shoes (Jiang et al., 2021a; Zhou et al., 2018; Zhou et al., 2021b; Xu et al., 2021; Zhou et al., 2021a; Gu et al., 2014), or ML unstable bionic shoes and unstable shoes (Zhang et al., 2012; Nigg et al., 2006; Pyo et al., 2008; Branthwaite et al., 2013; Sousa et al., 2014; Landry et al., 2010) will more or less reduce the moment and power of lower limb joints, which means that unstable footwear will indeed reduce the impact load of lower limb joints, which echoes the increased joint angle we mentioned in the previous article, and further proves our idea. However, the problem is that if the joint angle is increased and the lower extremity impact load is reduced, there must be other biomechanical characteristics that will change. Through further exploration and investigation, we found that for the two different types of unstable shoes, the AP unstable footwear tends to increase the number of muscles controlling plantarflexion and dorsiflexion of the ankle joint to compensate for the lower limb joint load, while the ML unstable footwear tends to increase the muscle strength controlling the inversion and eversion of the ankle joint to increase the protection of the lower limb organism.

Back when humans were first evolving, they did not need shoes for daily activity. As far back as 8300 years ago (Kuttruff et al., 1998), there is a record of people in the United States wearing shoes. Footwear usage may have contributed to the gracilization of pedal phalanges that was discovered in certain cultures around 30,000 years ago, according to biomechanics and anatomy (Trinkaus and Shang, 2008). Several fossil footprints from Kenya and Ileret have shown that people walked about 1.52 million years ago without shoes (Bennett et al., 2009; Richmond et al., 2010). Evidence for early human barefoot walking may also be found in other locations, such as South Africa, Tanzania, and Australia. The barefoot walking and running of certain indigenous cultures are still practiced today (Roberts, 2008; Richmond et al., 2011; Hatala et al., 2011; Webb et al., 2006). When traced back to the state of human foot development, we can find that in some people who have not been accustomed to use footwear so far, their foot shape is still maintained in an unstable condition ML, instead of saying that the sole of the foot has produced a similar rounded type of AP instability. This may be an indication that, at least under the conditions of natural human development, MBT shoes may not be a product of natural human evolutionary needs. Or rather, while MBT shoes may help the body increase instability and thus increase muscle engagement as a way to reduce joint impact loads, this structure may not be the best choice.

On the contrary, footwear similar to bionic shoes, which are unstable, will actually be more in line with the most original state of human beings. It can be said that MBT shoes bring more of a concept of "change", while unstable shoes and bionic shoes bring more of a concept of "return". But for adults, change may be easier to accept, because the help brought by footwear over the years has made contemporary people accustomed to it, and when this kind of instability suddenly appears, it may be even less acceptable, both in terms of mechanism function and subjective choice. But for children and adolescents, if this state of adaptation to unstable conditions on the ML is cultivated from an early age, it invariably increases the muscle function of the lower limbs for them, and this may be a completely new idea for footwear selection. Unfortunately, present study did not find any research in this area after extensive searching. This could be considered a research gap. It is also hoped here that this idea will be fully implemented in subsequent studies to help refine or create new ideas. We have to admit that there are several limitations included in this review. Firstly, this study only focuses on the study of the effect of unstable footwear on the biomechanics of the lower extremity, which has more or less some effect on the trunk. Secondly, this paper did not include high-heeled shoes and minimalist footwear in this study. Planned studies are underway that will refine and analyze separately these two categories.

CONCLUSION

This paper summarizes the functional arguments for unstable footwear in the recent research literature and to explore the different effects of various unstable designs of footwear in enhancing muscle strength training, improving stability and prevention of injuries. These collections and summaries allow for a better understanding and appreciation of the functions and types of unstable shoes, and an in-depth analysis of their pros and cons at the level of principles. It was also uncovered that AP unstable footwear is more suitable for fully developed adults, while for ML unstable footwear is perhaps more suitable for children and adolescents. The results reveal how two types of unstable footwear affect various movements and emphasize their significant influence within broader research. It is crucial for academics and industry practitioners to integrate and comprehend diverse research. Subsequent studies are needed to further prove our ideas and inferences, especially for children and adolescents, which require more effort.

COMPETING INTERESTS

The authors have no competing interests to declare.

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