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EFFECTS OF SHOE TYPE SOLE ON KINEMATICS, ELECTROMYOGRAPHY AND METABOLIC ACTIVITY

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ABSTRACT

Research has identified significant gait pattern changes as walking occurs on a level plane in flat sole sneakers. Prior research also highlights spatial parameter differences as speed fluctuates. Limited information, however, is known about variation in curved sole sneakers and the effect on kinematics, electromyography and metabolic activity. Recently, exercise companies have claimed that curved sole sneakers provide the individual with increased health benefits as they are said to burn more calories and shape body parts. Such sneakers would be extremely significant in the fitness realm to aid in weight loss and healthy behavior. Thus, the purpose of the experiment is to determine whether walking in curved sole sneakers significantly differs from flat sole sneakers at different speeds. I will analyze kinematic, electromyography and metabolic activity for both shoe types as individuals walk on a treadmill at 1.25mph and 1.75mph; flat sole 1.25mph walking will be used as the control.

Over a period of 6 months, 7 healthy female Pennsylvania State University students participated in the study. Each participant walked on the treadmill for each of the four parameters tested; flat sole 1.25mph, flat sole 1.75mph, curved sole (toneUP) 1.25mph, curved sole (toneUP) 1.75mph. Each trial lasted seven minutes and recorded spatial temporal variables, oxygen consumption (ml•kg-1•min-1) and the eight following muscles: TA, LG, SL, PL,VM, VL, BF, GM. A seven minute standing trial also occurred to record baseline oxygen consumption data.

Since little data have been researched on the fitness effects of curved sole sneakers, I based my hypothesis on the results of experiments using curved sole shoes for diabetic patients. I hypothesized that variable changes in all three parameters will occur due to the shoe formation.

Kinematic parameters such as stride time, ankle width, toe width and stance time will decrease. Additionally, I hypothesize that the muscle activity of the ankle stabilizers will increase when walking in the curved sole sneakers; more specifically, the TA and PL. Furthermore, I expect the metabolic activity will increase while wearing the toneUP sneakers. While the shoes will cause differentiation in the aforesaid variables, speed alone will also create variation. I hypothesize speed will cause a significant changes in EMG data. Due to the findings of past research, I also expect metabolic data too increase as speed increases.

TABLE OF CONTENTS

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CHAPTER 1: INTRODUCTION

Practical Significance

Numerous individuals constantly aim to improve their physique through aerobic activity such as walking. This trend has remained common due to the fact that aerobic exercise decreases body weight and helps improve cardiovascular health (Keenan et al., 2009). Current research demonstrates that shoe type and gait patterns play an important role in obtaining these desired results (Van de Walle et al., 2009). For example, when conducting level walking in flat-sole sneakers, individuals are 60-70% more cost-effective than when running (Schilling, 2011). Likewise, it has been identified that flat-sole athletic shoes decrease strain and force on the bodies joints; thus, relieving stress, increasing control and alleviating injury risks (Keenan et al., 2011).

Yet, big name athletic footwear companies are beginning to design sneakers that disregard the aforementioned research data praising flat-sole sneakers. Currently, numerous companies are promoting shoes, with a curved sole, that promise to increase muscle activity and energy expenditure; thus, guaranteeing consumers a better physique.

Several researchers have examined the effects of flat sole shoes and level walking (Royer et al., 2011; Gottschall et al., 2005; Keenan et al., 2011); however, little research has been conducted on toneUP shoes and their ability to increase energy expenditure and muscle movement. Furthermore, even less data has been conducted in comparing flat sole shoes to the innovative toneUPs.

Would the innovative toning shoes be useful for individuals aiming to lose weight and remove unwanted fat? If the shoes produce the desired results, those who are unable to participate in long walks would be able to obtain positive outcomes by walking only during daily activities. Likewise, the shoes would not force individuals to participate in extensive exercise, as body shape changes would occur from casual walking. Similarly, research proves that exercisers often drop out of daily physical activity regimens in the first six months (Mcauley et al., 1993). Therefore, individuals who rarely comply with exercise programs may see noticeable body changes more quickly; thus, encouraging these individuals to continue exercise or increase physical activity regimens. On the other hand, if the curved-sole sneaker decreases stability and increases fall risk, as shoes such as high heels have demonstrated, then the threat may be greater than the result (Blanchette et al., 2011). Through research pertaining to the aforementioned inquiry, I will be able to identify whether certain shoe types, effect kinematics, intensify muscle performance, or increase metabolic activity. Thus, this study aims to identify the differences in kinematics, electromyography data and metabolic expenditure between toneUPs and flat-sole sneakers

Kinematics

The measurement known as kinematics aims to identify the position of bony landmarks in space during movement. During my research, I will use this tactic to obtain results to determine gait patterns and stability changes during level walking with different shoes at different speeds. For instance, as an individual's speed is adjusted the body must compensate for this change by realigning the body; similar changes are presumed to occur as participants switch sneakers between flat-sole and toneUP sneakers.

Flat Sole Level Walking

Previous research has compared joint angles when walking with flat-sole sneakers at different speeds; such data will help me in creating a hypothesis consistent with my experiment.

As an individual begins to walk with flat sole sneakers, leg one propels toe off to initiate the walking motion as leg two remains on the ground to solidify stance (Rose et al., 1994). The leg initiating movement demonstrates hip extension, knee flexion and ankle plantar flexion, also known in biomechanics as toe off. While the toe is in contact with the ground, the gait cycle remains in the stance phase (Rose et al., 1994). As the body continues to propel forward, the hip reaches maximum extension and the toes discontinue contact with the ground; when the toes cease to touch the ground, the gait cycle is in the swing phase (Rose et al., 1994). At this point the toe needs to clear the ground so, the knee flexes and the ankle makes a 90 degree angle. When the mobile leg surpasses the standing leg, the hip flexes as the knee obtains a slight flexion in preparation for heel strike to occur. When the heel finally contacts the ground, the gait cycle has returned to the stance phase (Rose et al., 1994). As these aforementioned steps repetitively occur, individuals demonstrate a level walking gait cycle.

Curved Sole Level Walking

Little research has been conducted concerning curved sole sneakers and their effect on gait cycle. A study, however, was conducted which measured kinematics using a version of the curved sole shoe aimed to help diabetics during walking. Results demonstrated that when walking in the shoe the dorsiflexion, plantar flexion and inversion of joint movements were reduced (Boyer et al., 2009). While this research demonstrated a change at the ankle, no differences occurred at the hip or knee joints (Boyer et al., 2009; Wang et al., 2010). Therefore, this study highlights that during the gait cycle, curved-sole sneakers adjust the lower portions of the body, such as the ankle, while the knee and hip kinematics are left unaltered.

Furthermore, the rocker shoes gait patterns have been recorded previously during different walking speeds. The results deem that alterations in speed do not change movement patterns (Wang et al., 2010). Although the recorded data comparing various curved-sole sneakers seems consistent, it is also noted that the ankle kinematics change as heel shape/height changes (Wang et al., 2010). As a result, forcing the bodies muscles to compensate for the uneven shape by stabilizing themselves.

Similar to the curved-sole exercise shoe, research has been conducted on sneakers known as rocker shoes. Such shoes demonstrate a comparable shape as the shoes that I will use in my study. With that being said, the research expresses that the individuals in curved-sole shoes had a statistically significant increase in steps per minute compared to flat sole sneakers (Myers et al., 2006). Thus, for two people to walk equivalent distances one wearing the curved sole shoes must take more steps to reach the same destination as an individual in flat sole sneakers.

Hypotheses

After researching the aforementioned studies, I infer that individuals wearing toneUPs will demonstrate different general kinematic changes at the ankle joint. I hypothesize that the while wearing toneUPs during stance, ankle and toe step width will decrease. Similarly, past research leads me to believe that step length will decrease when wearing the curved sole shoes.

Likewise, I hypothesize that the kinematics will remain consistent at the different speeds when comparing the shoes vs. themselves. However, I hypothesize that that gait patterns will change when comparing the different speeds between the control and the curved sole sneakers.

Electromyography

Locomotion does not require all of the muscles to work simultaneously; during walking, some muscles will stabilize the joint (agonist), while others are activated causing an individual to progress forward. While an individual walks, various muscles are activated during the different phases of walking. For example, previous research denotes that electrodes display gastrocnemius stimulation during toe off; yet, the muscle is relatively inactive for the duration of the gait cycle (Colby et al., 1999). Since the exact amount of muscle activity taking place cannot be distinguished by the human eye, researchers frequently rely on electromyography (Rose et al., 1994).

The following study focuses on the eight following muscles: tibialis anterior, lateral gastrocnemius, soleus, peroneus longus, vastus medialis, vastus lateralis, biceps femoris and gluteus maximus. I will use surface electrodes to record the activity of the aforesaid muscles during level walking in both flat and curved sole shoes. I will be especially interested in identifying if the toneUP sneakers produce more muscle activity than the normal flat sole sneakers; a drastic increase would deem the curved sole shoes require an increase in work performed by the muscles during the gait cycle. Furthermore, the speed changes will be relevant in measuring whether speed effects muscle activity when wearing the two different shoe types.

Flat Sole Level Walking

The tibialis anterior (TA) is active during much of the swing phase to keep the ankle dorsiflexed at about 90 degrees (Winter, D., 1991). The role of the TA at this point is to ensure that the foot clears the ground without scraping. When the knee begins to extend and the foot is lowered to the ground, the TA still remains active to counter act the plantarflexing ground reaction forces (Winter, D., 1991). Therefore, the TA exhibits two bursts of activity, the first being during the swing phase and the second occurring as the heel reaches the ground to begin the stance phase (Otter et al., 2004). Previous level walking EMG results denote that the TA remains relatively inactive during rest of the stance phase and as toe off is initiated (Winter, D., 1991).

The lateral gastrocnemius (LG) elongates as the leg moves past the foot prior to toe off. As the foot initiates toe off, the LG contracts reaching peak activation (Winter, D., 1991). The contraction of the LG during toe off provides the leg with enough force to enter the swing phase. At about 40% of stride the LG activity decreases; however, some activity remains to aid knee flexion; at this time the lateral gastrocnemius is contracting opposite the vastus muscles (Winter, D., 1991)

Similar to the lateral gastrocnemius, the soleus (SL) aids in propulsion; thus, demonstrating peak activity during the conclusion of stance as toe off occurs (Otter et al., 2004). However, unlike the LG, the soleus does not originate superiorly to the knee joint; thus, the muscle does not perform concentric contraction to initiate knee flexion.

The peroneus longus (PL) muscle mainly aids in stability at the ankle joint. During one gait cycle, the PL demonstrates two peaks. The first occurs as the leg holds the majority of the body's weight in the middle of the stance phase (Winter, D., 1991). Another peak in activity is identified as toe off occurs; the PL operates to deter inversion of the foot (Winter, D., 1991). Throughout the swing phase, the PL aids the TA in obtaining dorsiflexion of the foot and while reducing its inversion (Winter, D., 1991).

Additionally, the vastus medialis (VM), a muscle apart of the quadriceps group, opposes the hamstrings by contracting to stabilize the knee during flexion. This opposition demonstrates the greatest peak, during weight acceptance (Winter, D., 1991). The VM is also active at mid stance immediately prior to toe off as the knee joint extends. Following toe off, the VM also counteracts the hamstrings to sustain an adequate angle of knee flexion during the beginning of the swing phase. The vastus lateralis (VL) demonstrates similar EMG readings during level walking.

The biceps femoris (BF) crosses both the hip and the knee joints; thus, the muscle is responsible for hip extension and knee flexion. During the gait cycle, the BF, like the gluteus maximus, is highly activated during stance (Winter, D., 1991). The muscles work to keep the body upright as the foot is on the ground. It is the most active as hip extension occurs in preparation for weight acceptance (Winter, D., 1991). Although the majority of activation occurs during hip extension, the BF is also useful following toe off to control forward motion as the knee flexes.

The gluteus maximus (GM) functions similar to the biceps femoris in aiding hip extension (Larsen et al., 2010). The GM demonstrates peak activation at the end of the swing phase; the muscle, like the BF, aids the hip during weight acceptance (Winter, D., 1991). The GM is increasingly active at this time to counteract the hip flexion. Likewise, the GM must control the pelvic tilt during weight acceptance; therefore, the muscle demonstrates a functional signal at this time. To ensure the thigh does not accelerate forward too quickly during mid swing, the GM is again activated to control the speed of movement (Winter, D., 1991).

Little information regarding different heel heights and varying walking speeds is found within scientific literature. Nonetheless, some research has compared extremely slow walking and normal walking in flat sole shoes. Since one of the main roles of the muscles, in walking, is to decelerate and accelerate the limbs to maintain a steady gait, the amount of muscle activation will vary depending on speed to ensure falling does not occur (Otter et al., 2004). Past research has demonstrated that the electromyography amplitude will increase as speed increases due to the need for a greater number of muscles fibers activated to propel movement (Otter et al., 2004).

Curved Sole Level Walking

Rarely has research been conducted on the muscles of individuals walking with toneUP shoes. Yet, extensive studies have measured individuals walking in shoes with various heel heights. Previous studies verify that as heel height increases the tibialis anterior becomes increasingly active to stabilize the ankle and prevent unwanted falls (Min-Lee et al., 2001). One study even found that the gastrocnemius remained contracted during the entire gait cycle when wearing sneaker with an increased heel height (Mika et al., 2012). On the other hand, vastus lateralis and the vastus medialis muscles do not aid in stabilization as heel height increases (Min Lee et al., 2001). With such data, many believe that as heel height increases the lower leg muscles activate so the gait cycle continues smoothly; however, the muscles above the knee that are utilized while walking with flat sole shoes are not heavily relied upon for stabilization.

While many of the muscles may not demonstrate an increased activation for stability, the upper leg muscles have displayed increased activation in aiding in knee flexion. As the heel height increases, knee flexion increases during the gait cycle (Mika et al., 2012). Therefore, muscles such as the vastus lateralis and vastus medialis will increase as the shoe height increases to aid in knee flexion.

Although the aforesaid data deduces that the lower limb muscles increase activation as heel height increases, not all research concurs. A new study conducted in February 2012 compared curved sole sneakers, marketed for weight loss, to those with flat soles; no significant EMG increases occurred (Sacco et al., 2012). Overall, the majority of previous research demonstrates significant information denoting that the leg muscles will increase activation as the heel height increases. Yet, the innovative research uses sneakers closest to those in my study which leads me to believe that this may not be the case.

Hypotheses

Prior research, leads me to believe that muscle activity will change as the individual switches shoes. I hypothesize that muscles assisting in stabilization at the ankle joint such as the TA and PL will be more active while walking in toneUP shoes than the regular sneakers. Due to the discoveries in recent literature, I further deduce that none of the other muscles will display significant changes based on shoe type compared to the control.

Likewise, I believe as the speed increases from 1.25mph to 1.75 mph the muscles will increase their activation regardless of shoe type. I further hypothesize that all of the muscles will demonstrate the most activity when the participant is wearing toneUPs and walking at a speed of 1.75mph.

Metabolic Activity

While an individual's normal gait patterns are the most metabolically efficient (Rose et al. 1994), many environmental factors, however, may influence metabolic cost such as treadmill speed. Recent research concludes that as physical intensity increases the amount of energy expenditure displays similar results (Dal et al., 2010). Walking speed has thus been deemed a crucial aspect in determining metabolic cost. In my study, I will be changing the treadmill speed from 1.25 mph to 1.75mph in order to further test speed's effect on metabolic activity.

For the experiment, I am interested in understanding the relationship between speed and metabolic activity. Likewise, I am concerned with what changes, if any, occur to the metabolic data as the participant switches from flat sole sneakers to curved sole shoes.

Flat sole level walking

Numerous studies have evaluated metabolic activity during level walking. One study demonstrated that walking on a level treadmill expends an average of .08 (VO_2 kg-1 m-1) at a speed of 1.3mph (Pontzer et al. 2009). One single average, however, cannot be provided for overall walking as the value changes based on intensity, duration, and age (Morgan et al., 2002; Dal et al., 2010).

Curved sole level walking

Although research has not been conducted on the metabolic cost of the toneUPs used in my study, studies have conducted analysis on diabetic rocker shoes. When walking in curved sole shoes on level ground an increased metabolic cost has been recorded (Hansen et al. 2011). The significant increase has been attributed to the instability of the shoes (Hansen et al. 2011); since the shoes cause unsteadiness, more muscles must be activated to maintain stability. Researchers believe that if agonist muscles are utilized to help stabilize against the antagonist more work occurs (Ortega et al., 2008). Thus, the body works harder and expends a greater metabolic cost than flat sole sneakers. Prior research concurs suggesting mechanical work and metabolic cost are intertwined; there is a direct relationship between the two variables (Royer et al., 2005).

Hypotheses

After reviewing the previous research studies, I hypothesize that metabolic activity, when wearing toneUPs, will increase because, as previously hypothesized, TA and PL activity will increase. Moreover, I believe that although not all of the muscles will increase activation, the increase in both the TA and PL will be significant enough to cause metabolic output to increase.

I also hypothesize that as the speed increases the metabolic activity will increase as well; however, I believe this will occur regardless of shoe type.

CHAPTER 2: METHODS

Participants

ToneUP experiment was conducted on various weekdays throughout a span of six months, September to February. Participants consisted of 7 college-age females. At the time of experimentation, each individual was enrolled at Penn State University and demonstrated no physical ailments that may affect data collection. Prior to beginning the experiment, participants signed an informed consent that follows Institutional Review Board and Pennsylvania State Human Research Committee protocols. Similarly, height, weight, and age were also recorded; the average height, weight and age of all participants are as follows: 1.6 meters, 54.5 kg, and 21.1years.

Prior to beginning the initial experiment, I had to compare the weights of both the regular sneaker and the toneUP. After careful measurement, I identified the toneUP weighed more. So, I had to add substance to the regular shoe so the data would be compatible. Therefore, to alleviate this incongruity, a package of black pellets was taped to the posterior portion of the normal sneakers. After adding the additional 0.077 kg of weight to the flat-sole shoe, I re-weighed each shoe to make sure all four shoes read similar numbers.

Overall, changes in the individual's movement were measured through three forms of data collection: kinematics, electromyography and metabolic VO_2. The kinematic data was acquired by using surface kinematic markers; I measured electromyography by placing electrodes on 8 different muscle bodies. The latter was calculated by use of a VO_2 analysis system. All of the aforementioned data collections occurred during 5 different, 7 minute trials. The initial assessment measured standing VO_2 max; followed by, randomized conditions of two regular sneaker and two toneUP walking trials at speeds of 1.25mph and 1.75mph. All motion trials were conducted on a level treadmill.

For kinematic measurements, reflective markers were placed on areas of the body. Consistent with prior research, I used this strategy to capture gait of the participant and trajectory of the reflective markers (Rose et al., 1994). 17 kinematic markers were positioned on each participant. The bony landmarks used for placement were cervical vertebra #7, sacral crest, left and right anterior iliac crests, right lateral iliac crest, lateral right thigh, left and right lateral tibial condyles, lateral left shank, and left and right lateral malleous(s). Similarly, both the regular shoes and toneUPs received reflective markers on the left and right heels, the distal portion of the 5^{th} phalange on both the left and right foot and both distal phalanxes of the great toe. To prevent detachment, I secured the kinematic markers to each of the aforementioned areas with adhesive tape.

In order to obtain electromyography readings, I utilized surface EMG techniques specialized in identifying muscle movement; 8 muscle bellies were identified on the left leg; tibialis anterior, lateral gastrocnemius, soleus, peroneus longus, vastus medialis, vastus lateralis, biceps femoris and gluteus maximus. To identify the origin and insertion points, I used a tape measure. After identifying each muscle, I followed provided guidelines which highlighted the placement of the specific muscle bellies. When the instructed areas were established, I used a black marker and made a small mark. To ensure that the electrode would remain adequately secured throughout the experiment, I cleaned the specified area with rubbing alcohol and sandpaper. Then, I put two 2cm bipolar spacing electrodes on each marked area in the direction of the muscle fibers. By pressing the adhesive side of the desired electrodes firmly to the skin, I further solidified them to the surface of the leg.

Specifically, I identified each of the 8 muscle bellies by following a repetitive process. For the tibialis anterior, I held one end of the tape measure at the origin, lateral tibial condyle, and the other at the insertion, the medial surface of the first metatarsal. At this time, I followed the provided instructions and palpated down 1/3 of the tape measure. To identify the gastrocnemius, I identified the head of the fibula. Then, I measured from this point to the insertion (calcaneus); 1/3 between the two points is the muscle belly. The soleus, which is more deep and inferior than the gastrocnemius, is palpated from the same two points; however, the soleus muscle belly resides about ½ the distance between the fibular head and the calcaneus. To distinguish the peroneus longus, I palpated about 2-3 inches superior to the lateral malleolus. The vastus lateralis is located 3-5cm superiorly and laterally from the superior border of the patella. Since the vastus medialis originates at the posterior medial femur and inserts at the superior border of the patella, I used the tape measure to identify the two points. Then, I measured about 2-4cm superiorly and medially from the insertion; this position describes the muscle belly of the vastus medialis. Furthermore, after palpating the biceps femoris tendon, I moved 4-6cm superiorly to identify the biceps femoris muscle. Lastly, the gluteus maximus is located by palpating about 2-3cm below the posterior medial region of the ilium. In order to pinpoint the area, I had each participant laterally extend her leg against a door, which was used to provide resistance.

After isolating all 8 muscles and attaching the electrodes, I fastened lead lines to the metal portion of each device. The EMG wires were then collected and bundled together near the participant's greater trochanter of the femur. While I held the lead lines, each individual was instructed to tuck in her shirt to her shorts. At this time, I wrapped pre-wrap around the area to fasten the EMG wires to the waistline. In order to ensure the wires did not become detached from the electrodes during the experiment, I made sure each lead line was neither too taught nor too loose against the body. Next, I fastened the EMG battery pack to the individual's waist. While I secured the belt to alleviate any drastic belt movement during the level walking trials, participants were instructed to tighten the belt to a snug position. After fastening the EMG belt, I inserted the wires into the specified positions. Finally, the battery pack was connected to the computer via a wire.

In order to test that the EMG electrodes were positioned on the correct muscle bellies, I instructed participants to perform numerous functional tests. The tibialis anterior was tested by asking the participant to rock backwards onto her heels. To assess the gastrocnemius and the soleus, the individual stood on her toes. The peroneus longus was tested by inverting and everting the foot. To identify both the vastus lateralis, and vastus medialis I directed one's left leg parallel to the ground while her right leg remained stationary on the ground; instructing individuals to contract these muscles while lifting produced the greatest results. By moving the calcaneus toward the gluteal tuberosity, the biceps femoris was assessed. In order to test the gluteus maximus, I instructed participants to raise their leg laterally while I added an opposing force to this action. Such resistance required the gluteus maximus to work harder; thus, the EMG recorded increased muscle action. To further solidify all electrode placements were correct, participants held a squat for about 10-15 seconds.

Next, metabolic analysis was conducted to measure metabolic activity. A mask apparatus, that surrounded the circumference of the individual's head and entered the mouth by a tube, was utilized to record breathing activity. The mask was comfortably positioned on the participant's head; yet, it was tight enough that jostling would not occur during the walking experiment. To eliminate the individual from breathing from the nostrils, a nose clip was clamped on the nose.

Protocol

To begin the experiment, the individual performed a standing metabolic trial where she stood with her feet shoulder width apart, arms relaxed and knees slightly bent. The analysis was conducted on level ground and lasted for seven minutes. An initial collection aimed to record baseline metabolic rate.

After the VO_2 standing trial, participants removed their personal sneakers and put on either the flat-sole sneakers or the toneUPs. None of the experiments followed consistent shoe order; therefore, the conditions were randomized for all 7 participating individuals. After the participant got on the treadmill, she used metal bars to lift her body vertically so I could start the machine at either 1.25mph or 1.75mph. Similar to the unsystematic shoe selection, the speeds were also randomized.

After one of the two speeds and shoe types was selected, the individual walked on a level treadmill for 7 minutes. While walking, the metabolic and EMG data was collected. Likewise, 3-D motion cameras recorded the data from the kinematic markers. Metabolic analysis was recorded during the entire seven minute trial; however, to forgo an abundance of data, both the EMG and kinematic data were collected every 30 seconds for 20 second durations. When the seven minute trial concluded, the treadmill was stopped and speed was modified to which ever pace had not been previously used. The aforementioned steps were followed again as the participant walked for seven minutes at the new speed; shoes were not changed at this time. Following the two speed trials, however, the individual changed shoes and the process was repeated.

Statistical Analysis

Kinematics, EMG and metabolic activity were analyzed across conditions using a repeated measures design (ANOVA). Where appropriate, Newman-Keuls post hoc tests and paired t-tests for the metabolic data were constructed to analyze the differences between conditions. Significance, and therefore statistical difference, was defined as $p \leq 0.05$.

CHAPTER 3: RESULTS

Kinematics

The average spatial-temporal parameters for each of the four conditions are displayed in Table 1. The table also signifies which results prove statistically significant when compared to the control (Flat Slow).

	Flat Slow	Flat Fast	toneUP slow	toneUP fast
Stride Time (ms)	**100**	**86.1**	**97.2**	**84.2**
Swing Time (ms)	100	92.9	107.9	**87.2**
Stance Time(ms)	**100**	**81.7**	**90.4**	**82.4**
Step Length	**100**	**117.0**	99.8	**117.36**
Ankle Step Width (mm)	100	55.0	87.0	-117.6
Toe Step Width (mm)	100	-10.2	65.5	-32.5

Table 1: Representation of spatial temporal parameters with noted significance values. The variables demonstrating significance to the control are in bold.

The results demonstrate that significance occurred for all stride time variables when compared to the control. As the speed increases stride time exhibits a decrease for both the flat sole and curved sole. Both scenarios displayed similar results in expressing about a 14% decrease comparatively.

Table 1 further reveals swing time averages which also demonstrate decreases as speed increases. However, the various speeds demonstrate little significance when observing swing time. The only statistically significant variable when comparing to the control is toneUP fast. Such a result leads to the deduction that swing time decreases significantly when walking in toneUPs at 1.75mph compared to walking in flat sole sneakers at 1.25mph. While not statistically significant, the toneUP shoes demonstrated a 12% greater difference than the regular. Furthermore, Table 1 identifies that the longest amount of swing time occurs during toneUP walking at 1.25mph.

Similar to stride time, stance time revealed significance for all for elements compared to the control. As the speed increases the stride time decreases which is consistent with my aforesaid hypothesis. An 18% and 8% decrease occurred between the respectable variables. It is also important to note that stance time between toneUP slow and toneUP fast reveals significance.

Step length data identifies significance between the control and the flat fast trial; about a 17% increase in step length occurs as speed increases. Although the toneUP slow trial does not demonstrate significance with the control, the variable does display significance with the toneUP fast. A 17% increase occurs between these two situations. Overall, however, the slow trials for both shoes reveal about the same average at about 100 and the fast trials deduce an average at around 117. Therefore, the shoe type did not make a difference in step length which is contrary to my hypothesis.

Additionally, no significant statistics change with ankle step width. Although Table 1 forgoes significance findings, it is noteworthy to highlight that the difference between toneUP fast and slow is over 200%; similar conclusions can also be made between the toneUP fast and the control. The toneUP fast displays the greatest decrease in ankle step width with a numerical value of -117. Analogous findings are also exhibited in the toe step width category. None of these comparisons express significance though the data does show that as speed increases toe step width decreases.

Electromyography

The EMG results reflect the altering muscle activity of 8 different muscles as speed and shoe type changes.

The TA, during level walking, demonstrates the most activity throughout initial stance, mid and terminal swing. In the initial stance phase, the activity of the TA increases by 44% as speed changes from 1.25mph to 1.75mph while wearing flat sole sneakers. Different than hypothesized, the slow walking in toneUP shoes demonstrates less activation than regular sneakers during initial stance. In both initial stance and mid swing, no significant changes occur between the regular flat sole sneakers and the toneUPs. However, throughout terminal swing the TA displays a significant 62% increase from 1.25mph and 1.75mph while wearing toneUPs. Overall, in all three situations, the activation of the TA increases as speed increases. Table 2 reveals TA activity more in depth during the aforementioned three portions of the gait cycle.

GAIT CYCLE	Flat Shoe Slow	Flat Shoe Fast	toneUP Slow	toneUP Fast
Initial Stance	100	143.65	75.35	112.43
Mid Swing	100	126.42	121.36	126.99
Terminal Swing	100	157.76	108.57	169.77

Table 2: TA activity during the most active portions of the gait cycle

During walking, the lateral gastrocnemius displays peak contraction as toe off occurs; very little activity is recorded otherwise. Table 3 highlights the activation of the LG during the portions of the gait cycle which surround toe off: late stance and terminal stance and initial swing. As demonstrated in the table, the activity of the LG increases as speed increases. Similarly, little significance is recorded. Notably, numerical significance occurs during mid stance between the toneUP sneaker trials; about a 36% increase occurs at this time. Furthermore, throughout late stance, .024 significance occurs between the flat sole shoe trials. Contrary to my hypothesis, the LG does not display significantly more activity when wearing the toneUP shoes. It is interesting to note, however, that during stance, the recorded toneUP slow values are lower than flat shoe slow values; however, throughout swing the toneUP slow quantities are higher than the slow walking flat sole numbers.

GAIT CYCLE	Flat Shoe Slow	Flat Shoe Fast	toneUP Slow	toneUP Fast
Late Stance	100	**153.4**	87.3	133.8
Terminal Stance	100	120.5	97.0	120.9
Initial Swing	100	**129.5**	109.3	114.0

Table 3: LG activity surrounding toe off. Bold values are indicating significance.

Similar to the LG, the soleus demonstrates peak activity at toe off. However, unlike the LG, the soleus does not display any significant increases or decreases throughout any of the walking trials. The SL is more active as speed increases which is demonstrated in Table 4. On average, the SL activity increased by 20.5% (flat sole), and 16.3% (toneUP) as speed increased, during the three most active portions of the gait cycle. The soleus revealed the most activity occurred during late stance while wearing the flat sole shoe and walking at a speed of 1.75mph. Moreover, opposing my hypothesis, the SL displays more activation while wearing the flat sole shoe than the toneUPs when comparing the trials of the same speeds.

GAIT CYCLE	Flat Shoe Slow	Flat Shoe Fast	toneUP Slow	toneUP Fast
Late Stance	100	129.7	84.5	117.5
Terminal Stance	100	106.2	93.0	98.9
Initial Swing	100	125.6	96.3	104.5

Table 4: Numerical values of activation for the Soleus throughout the walking trials.

Furthermore, the results deduce that the PL stabilizes the ankle at initial and mid stance. During initial stance, none of the variables demonstrate significance with the control. Yet, there is a significant 39.7% increase in PL activation between the toneUP 1.25mph trial and the toneUP 1.75mph trial. Throughout both initial and mid stance the PL amplifies in activation as speed increases. The toneUP 1.25mph trial demonstrates PL reduction compared to the control; both the toneUP and regular 1.75mph trials reveal PL activation increases compared to the control. The PL also signifies a peak in activation as toe off occurs to reduce ankle inversion. The toneUP 1.75mph trial demonstrates significance ($p=.039$) when compared to the control. Table 5 signifies that the most PL activation occurs throughout late stance in regular sneakers at 1.75 mph.

GAIT CYCLE	Flat Shoe Slow	Flat Shoe Fast	toneUP Slow	toneUP Fast
Initial Stance	100	136.5	83.0	122.7
Mid Stance	100	118.9	93.3	143.4
Late Stance	100	141.55	93.6	**140.8**

Table 5: PL activation during the stance phase. Bold numbers illuminate significance.

The vastus lateralis muscle contracts stronger as speed increases. Yet, no consistent data was found when comparing the two different shoe types at the same speed. As found in previous research, the VL is stimulated throughout stance as the muscle aids in stabilizing the body and knee extension. Notably, the only significant numerical values are found during late stance. Although none of these values are significant compared to the control, it is important to note that the 32% increase between toneUP slow and toneUP fast demonstrates significance (p=.004). As expected, the highest VL activation is seen as the leg is extended in initial stance: 139.32. Table 6 further explains the VL activation data.

GAIT CYCLE	Flat Shoe Slow	Flat Shoe Fast	toneUP Slow	toneUP Fast
Initial Stance	100	139.32	93.5	143.11
Mid Stance	100	103.6	79.1	96.2
Late Stance	100	118.4	85.6	117.8

Table 6: Representation of the VL throughout the portions of the gait cycle which the muscle is most active.

The vastus medialis' function is similar to the VL. Correspondingly, the data was repetitive and displayed no significance compared to the control for any variables.

During a walking gait cycle, the biceps femoris demonstrates peak activation throughout the various stance phases. As demonstrated in Table 7, the BF activity increases as speed increases. However, a pattern is observed throughout the gait cycle which is worthy of noting; the BF is less active when wearing toneUPs than regular flat sole sneakers. For example, during initial stance when the muscle is most active, the BF while wearing toneUPs at 1.25mph decreases by 19% compared to the control. Likewise, the flat sole fast trial displays a BF activation of 125; yet, the BF activity while wearing toneUPs reveals a reading of 112.4 at the same speed. Thus, the numbers oppose my hypothesis. Although the aforementioned patterns are observed, none of the numbers are deemed significant following analysis.

GAIT CYCLE	Flat Shoe Slow	Flat Shoe Fast	toneUP Slow	toneUP Fast
Initial Stance	100	125.3	80.8	112.4
Mid Stance	100	109.8	82.7	107.3
Late Stance	100	125.0	89.8	125.5

Table 7: Values representing BF activation throughout the gait cycle.

Similar to all of the aforementioned muscles, the gluteus maximus increases in activation as speed increases; Table 8 provides exact numerical values of GM activity during the muscles most active portions of the gait cycle. As identified in prior research and also consistent with my hypothesis, the GM is most active at the mid and terminal swing portions of the gait cycle. Compared to the control, the GM demonstrates a 35.5% increase in activation during mid swing when walking in regular sneakers at 1.75 mph; such a result demonstrates significance (p=.015). A valuable increase in GM activity is seen similarly throughout terminal swing; the increase is 29.4%. The data also proves that the greatest GM stimulation occurs when walking in flat sole shoes at 1.75 mph. It is interesting to note that, although not substantial, while in mid and terminal portions of the gait cycle the GM decreases in activation during toneUP slow walking compared to the control. The aforesaid pattern is seen throughout the entire gait cycle besides initial swing. Likewise, the GM activation is greater while wearing flat sole sneakers and walking at a pace of 1.75 than wearing the toneUPs at the same speed. Overall, the toneUPs do not significantly increase GM activation.

GAIT CYCLE	Flat Shoe Slow	Flat Shoe Fast	toneUP Slow	toneUP Fast
Initial Swing	100	132.1	107.7	119.1
Mid Swing	100	**134.5**	98.3	111.7
Terminal Swing	100	**129.4**	97.5	116.8

Table 8: GM data during the four variable trials. Bold numbers demonstrate significance when compared to the control.

Metabolic Activity

Figure 1 demonstrates the average VO_2 for the seven participants in each of the various trials; unit of measurement is ml•kg-1•min-1**.** As expected, the standing trial is substantially lower than the actual trials and was used as a baseline reading. The control demonstrated an average metabolic rate of 9.07 ± 1.2 ml•kg-1•min-1.

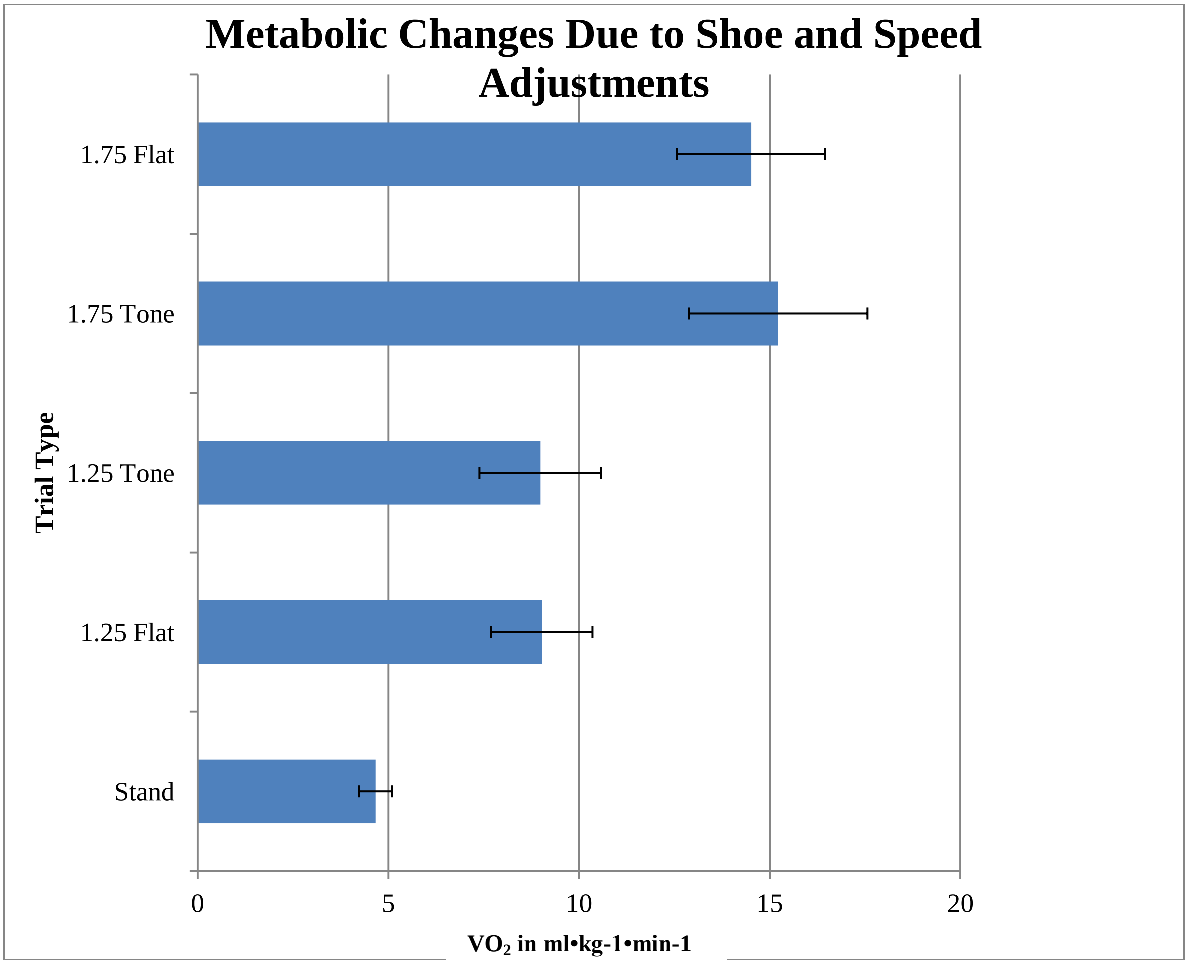

Figure 1: Average VO_2 for each of the trials conducted throughout the experiment

Opposite to my hypothesis, the metabolic data for the 1.25mph toneUP walking trial was less than the 1.25 normal shoe; however, the difference is subtle. 1.25mph toneUP demonstrated 8.99 ±1.6 VO_2 in ml•kg-1•min-1 while the latter displayed metabolic data of 9.07 ± 1.2 VO_2 in ml•kg-1•min-1. Therefore, it is important to note that the numbers are similar eliminating any significant differences.

Confirming my hypothesis and similar to the results of prior research, the metabolic output increases as speed increases. More specifically, the 1.25mph results demonstrate an average of about 9.00± 1.4 VO_2 in ml•kg-1•min-1compared to the 1.75mph average of 14.87±

2.2 VO_2 in ml•kg-1•min-1. Furthermore, Figure 1 demonstrates a substantial significant increase in metabolic work from standstill to 1.25 mph in both shoe types. Thus, the aforesaid numerical values further solidify that walking speed effects metabolic work.

Although the data is not significant, it is noteworthy that the toneUP sneakers at 1.75mph demonstrate a higher metabolic work than the flat sole sneakers at 1.75mph: 15.23± 2.3 VO_2 in ml•kg-1•min-1 vs 14.51 ± 1.9 VO_2 in ml•kg-1•min-1. Such findings are consistent with previously conducted research; however, the number is only slight and not substantial. Likewise, Figure 1 denotes that, throughout the study, the most metabolic work occurred when wearing toneUPs at a speed of 1.75mph

CHAPTER 4: DISCUSSION

Although other curved sole shoes have exemplified dramatic variable changes, the toneUP shoes do not demonstrate fitness company's desired results for aiding in increasing weight loss. The following gait variables, stance and stride time, demonstrated significant changes when contrasting all three variables to the control. Step length also reveals interesting data discouraging the effect of shoe type on the data. Compared to the control many muscles such as the LG, SL, BF and GM did not increase activity while walking in the curved sole shoe at the same pace; therefore, refuting my claim that the most significant activity would occur during curved sole walking at 1.75mph. Although many times insignificant, muscles surrounding the ankle increased as speed increased. Likewise, toneUP distributors claim that the curved sole formation will cause an increase in GM activation compared to the control which will in turn lead to more toned backside. However, the data collected opposes the theory by demonstrating that a significant increase in GM activity only occurs when wearing flat sole shoes at 1.75mph. Lastly, in accord with my hypothesis, metabolic activity was significantly greater as speed increased.

Kinematics

Throughout out the experiment, I measured numerous spatial-temporal measures such as stride time, swing time, stance time, step length, ankle step width and toe step width. Although many of the results remain inconclusive, stride time, stance time, and step length parameters have provided me the opportunity to identify a few overall gait changes.

Stride time displays a decrease across all variables compared to the control. Correspondingly, as revealed in previous data, stride time and speed are inversely related

(Bollens et al., 2012). The decrease, however, may not only occur due to increased speed as a significant decrease is also evident as shoe type changes. Confirming my hypothesis, the data also demonstrates significant decreases ($p<.05$) in stance time for every variable compared to the control. Similar data, although not statistically significant, was identified when examining diabetic rocker shoes during level walking (Myers et al., 2006).

The limited amount of data focusing on curved sole weight loss sneakers provides little information for considerable comparison. However, the curved sole shoes are shaped so neither the heel nor toe lay flat on the ground. So, as the body is carrying out the gait cycle, the shape of the shoe aids in the propulsion of stance to swing (Albright et al., 2009). Although this theory may have some validity in contrasting the control to the curved sole shoe, it does not explain the decrease in stance time while comparing the control to the flat sole shoes at 1.75 mph. Past research visited the idea of increasing running speeds on stance time; the information eluded that as speed increases, a reduction in stance time occurs (De Wit et al., 2009). As a result, I assume that both speed and shoe type played a role in the reduction of time spent in the stance phase of the gait cycle. However, I do suppose that if a single shoe type was consistently worn at various speeds a similar effect would transpire.

Contrary to prior research, (Long et al., 2007) the step length significantly increased compared to the control when walking in both shoe types at 1.75 mph; however, very little change occurs when comparing the control to the curved sole at 1.25mph. Similarly, while a significant step length increase did occur during the two trials, it is interesting to note that both the flat and curved sole shoes displayed almost the exact same numerical value at 1.75mph. Research infers that as speed increases step length will also increase to ensure stability

(Sekiya et al., 1998). This fact indicates that the increase in step length is likely due to increased speed and therefore, suggests that shoe type does not influence step length.

Additionally worth noting, step and toe width decreased in all trials compared to the control. Although the values were insignificant, the toneUP slow and fast trials emphasize a step width difference of about 206mm. Significant decreases in step width have been identified in previous research as an alteration in gait to obtain lateral balance (Arellano et al., 2011). Since the curved sole shoe displays a unique form and less friction with the ground, the shoes are believed to cause instability. Therefore, I presume that step and toe width decrease to aid in stability and compensate for structural differences in the toneUP shoe.

Electromyography

As previously discussed, the following 8 muscles were tested during the experiment: TA, LG, SL, PL, VL, VM, BF, and GM. Each muscle is activated during the gait cycle depending on its function. After reviewing the results, many of the muscles demonstrated results opposing my hypothesis and left numerous alleys for further research.

The tibialis anterior demonstrates peak activity throughout mid swing, terminal swing and initial stance; however, the results deduce that zero significance occurs between the control and the other three variables. Interestingly, however, it is important to note that changes in TA activity during curved sole walking from speeds of 1.25mph to 1.75mph increase by about 40-50. Although such values are not significant, I suppose that as speed increases the TA must work harder to clear the toe and safely enter the stance phase without considerable foot eversion (Segers et al., 2007).

With one exception, the LG, SL, BF, GM all reveal insignificant decreases in muscle activity when comparing the 1.25mph curved sole to the control. Although all of these values are insignificant, I deduce that it is important to note that the toneUP shoe is not demonstrating any, insignificant or significant, increases in activation compared to the control. This is especially important because the aim of shoes exemplifying a curved sole shape is to cause the body's center of mass to shift posteriorly forcing the aforesaid four muscles to demonstrate greater activity (Tyrrell et al., 2009). I have found that, of the four stated muscles, the only time which the curved sole shoe demonstrates greater activity than the control is when the LG reaches initial swing; however, the value is also insignificant. Therefore, the data agrees with my hypothesis that it is unlikely that the sneakers are fulfilling their intended purpose of toning the LG, SL, BF, and GM muscles by increasing activation or causing any significant effect.

Moreover, a major problem area of overweight women is their gluteus maximus; hence, why the marketing strategy used by toneUPs distributors may sound appealing. Nonetheless, compared to the control, the GM only significantly increases activation while walking in the flat sole shoes at 1.75mph. Furthermore, as stated above, the GM actually decreases in activity when walking in toneUPs at 1.25mph compared to the control. Likewise, the GM is more active when walking in the flat sole shoes at 1.75mph than the curved sole shoes at either of the tested speeds. The aforementioned information refutes my hypothesis because the greatest muscle activity does not occur during the curved sole 1.75mph trial. All of the GM results further discourage the possibility that the curved sole shoe is enabling the GM to increase activity and thus substantially tone the problem area.

Furthermore, the shape of the curved sole sneaker forces the toe and heel portions of the foot to be raised above the level ground surface. Due to the unique shape, less surface area is available to create friction with the ground (Blanchette et al., 2011); therefore, as previously stated, muscles of the lower leg must compensate to aid in stability. The PL, which functions to help stabilize the knee joint, agrees with my hypothesis in revealing a significant increase in activation when walking in the toneUP and flat sole shoes at 1.75mph. Yet, although not significant and contrary to my hypothesis, the PL decreases in activity when walking in curved sole shoes at the same speed as the control.

Previous research has examined the same issue using rocker sole diabetic shoes. Despite the latter of my two PL findings, prior experimentation highlights that compared to the flat sole shoes, curved shoes alone display a significant increase in ankle angle (Boyer et al., 2009), which causes an increase in activation in muscles such as the PL, TA or any other muscle crossing the ankle joint. Due to the conflicting results, I can infer that PL activity will be greater while wearing the toneUPs at increased speeds; however, further research is needed to conclusively state whether a trend is evident while comparing the toneUPs at a constant speed.

Metabolic Activity

The metabolic activity was recorded for all 7 participants during the standing and the four other trials. Nonetheless, the results were not conducive to the shoes intended purpose.

The data varied little when comparing the control with the curved sole shoe at 1.25mph. Similar results were seen as the flat sole and curved sole were compared when both were worn at a pace of 1.75mph. However, significant changes in metabolic activity did occur as the control was compared to both 1.75mph trials. Overall, little change occurred between shoe types when compared at the same speed; yet, the only drastic significant changes occurred as speed increased. From the data, I deduce that the shoe type variable did not affect metabolic activity.

Prior research explains that when comparing running to walking, in this case uphill walking, ventilation is 7.80 ($1\cdot m^{-1}$btps) higher during running than walking (McMurray et al., 1982). Hence, speed alone can have a dramatic effect on metabolic activity.

Since research has not been conducted comparing my constructs, I also evaluated my findings against a study contrasting individuals with ankle arthrodesis walking in curved sole shoes and healthy patients in flat sole shoes. Contrary to my findings, this research highlights that significant increases in metabolic activity occur when walking in curved sole shoes compared to flat sneakers; about a 7.6% was identified (van Engelen et al., 2010). For this greater increase in metabolic activity to occur while wearing the rocker sole shoe, the individual had to have an additional ailment.

Furthermore, I assume that the differences in TA and PL muscle activity were not enough to effect metabolic activity. Presumably, an ailment such as ankle arthrodesis has forced the muscles of the lower leg to work harder to compensate for the bone weakness. Therefore, increased work would occur causing the previously mentioned increased metabolic activity.

After relating the aforesaid data with my own, I believe that, contrary to my hypothesis, the curved sole shoe is not the cause for any observed increases in metabolic activity. Moreover, any significance found throughout my data is most likely not associated with the shoe type but, instead do to another variable such as speed.

Limitations

Because little literature compares curved sole shoes, intended for weight loss, and flat sole shoes, I had to draw general hypotheses from research that uses curved sole shoes for other purposes and other data comparing shoes with increased heel heights. Since the nature of the experiment was innovative, I had to control for numerous variables.

When using a VO_2 apparatus to record participant's metabolic activity, the individual is breathing through a tube as she walks. However, the tube's length is long and does not allow for expired air to reach the machine until about 17 seconds after a breath is taken. For accurate metabolic data, a machine would have to record respiration directly after each breath. Therefore, my metabolic activity data may be skewed due to this limitation.

If the individuals partaking in the experiment consisted of extremely diverse BMI and weight measurements, the recorded metabolic activity would distort the data by forcing outliers causing skewed numerical values. Therefore, since I did not have access to the intended consumers of the toneUP sneakers for my experiment, I used a group of 7 homogeneous healthy college females. Previous research, however, denotes that obese adults expend 0-33% more metabolic cost than those possessing a normal weight (Browning et al., 2005). Hence, a contradiction occurs between the participant pool and the desired consumers. Thus, I was limited to only speculating the type of effects the shoes would have on the older, overweight female population.

Lastly, in order to evaluate gait patterns of both curved and flat sole shoes at a single speed, the conditions for each participant were randomized. Such a tactic was implemented so each situation could be evaluated on its own merit. Performing one continuous trial that followed a specific order of scenarios would have skewed the data as the individual may become fatigued, causing metabolic activity to increase and slanting both kinematics and EMG values. Additionally, I randomized the conditions so the trials were not always occurring in specific order to ensure that the results were consistent no matter when they occurred throughout the experiment. Yet, a limitation exists as all of the measurements were performed on the treadmill and do not demonstrate variability of terrain and speed that naturally occurs during walking gait.

Future Research

Since little research exists pertaining to curved sole sneakers for fitness purposes, future experimentation is needed. For example, our participant pool consisted of 7 healthy college age students; however, the target market of the product is older overweight women. Prior research deduces that, at a set pace, metabolic cost is 11% greater during flat sole walking in overweight women than those which are healthy (Browning et al., 2005). Therefore, potential research should allow for the desired consumers to act as participants for more accurate results. Additionally, increasing the number of participants may be beneficial. A small sample size limits the amount of data recorded; more variables provide greater comparison and may solidify current results or uncover unbeknownst information.

Moreover, the present research lasted seven minutes at set speeds; yet, normal walking speeds vary throughout the gait cycle. Previous research further explains that an obese woman's desired walking pace is much less than that of a fit woman (Browning et al., 2005). Perhaps, a study should test whether numerous varying speeds effect the kinematic, EMG, and metabolic criteria of curved sole walking. Similarly, terrain variation and the addition of hills will affect gait. For example, consider an overweight woman walking for an hour outside in toneUPs for daily exercise. The lab results found in my study do not contain conclusive information verifying whether toneUPs effect exercise durations, varying walking speeds, or outdoor conditions. Forthcoming research should alter the trial types and speeds beyond the four mentioned conditions.

While little research has been conducted on walking with toneUPs, no experiments exemplify kinematic, EMG, or metabolic activity during running while wearing the shoe; Although running in similar shoes has been researched, ankle stability while running in toneUPs is unknown. Therefore, companies may understand the insignificance of toneUPs effect on walking; however, is it surreal for these companies to market the shoes as running tools for increasing weight loss? Although prior research leads to the speculation that this would be dangerous, further research should be conducted to find out whether increased speed provides immense strain, or is hazardous for consumers.

Practical Application

Innovative weight loss mechanisms are increasingly popular as the overweight population continues to grow; about 63% of adults in the United States demonstrate an unhealthy weight (Clune et al., 2010). Recently, sneakers claiming to enhance weight loss by varying kinematic variables and increasing metabolic and muscle activity have appeared at the forefront of the market. Therefore, the aforesaid research was important in identifying whether fitness company's claims are legitimate.

After an in depth review of the results, the numerous insignificant and inconclusive results ascertain that the shoes do not sustain intended promises. While the toneUPs do vary the gait kinematics compared to the control, these alterations do not differ enough to considerably increase muscle activity. Throughout my research, I found many of the eight muscles tested, such as the LG, SL, BF and GM, decrease in activation when walking in toneUPs at the same speed as the control. Likewise, since wearing the toneUPs does not significantly increase the activity in a majority of the muscles, the metabolic expenditure caused by shoe type does not dramatically increase. Additionally, prior studies on curved sole shoes have demonstrated an adverse effect by causing muscle straining or damaging surrounding tissue (Tyrrell et al., 2009). Seeing as the toneUPs do not significantly vary kinematic, EMG or metabolic parameters compared to flat sole sneakers, I would not recommend the toneUPs to the vast overweight population.

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RELEVANT EXPERIENCE:

August 2011- Present
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Biomechanics Laboratory: Student Researcher
Primary Responsibilities: Investigate the effects of shoe type on kinematics, electromyography, and metabolic activity at different walking gait speeds

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