EZ Running Belt eliminates heel-strike
-Case series

Kim André Sveen

THE SWEDISH SCHOOL OF SPORT AND HEALTH SCIENCES
Graduate essay: 29:2013
Master program 2012-2013
Supervisor: Emma Hawke
Examiner: Karin Söderlund
Abstract

Aim: The purpose of the study is to explore within a case-study design if training with the EZ Run Belt in an ecological setting changes running kinematics and if it affects running economy.

Methodology: A case study design has been chosen to answer the aim of this study. Four subjects (two men, two women) with different running background were recruited for this case study, but only two subjects completed the study. Subjects visited LIVI test laboratory on two different test sessions. The study design consisted of one pre-test followed by a 4-week training intervention and a post-test and it was administered as a case study. The training intervention was conducted in an ecological setting with no interference from the researcher. The study consisted of an economy test and a kinematic test. The subjects ran the test on a treadmill at two different self-selected submaximal paces (6 min each). Submaximal running economy was defined by the average VO$_2$ (l·min$^{-1}$, ml·kg$^{-1}$·min$^{-1}$) recorded over the last minute of each 6-min bout. Running kinematics was analyzed from video footage with the video analysis software Kinovea.

Results: Both subjects eliminated heel-strike, increased step frequency, shortened stride length while the energy cost increased.

Conclusions: The EZ Run Belt could be a good tool for heel-strikers as it eliminated heel-strike and helped with changing the stride into a more forefoot strike in the two case studies presented.
# Table of content

1. Introduction ........................................................................................................... 1

2. Literature review ..................................................................................................... 2
   2.1. Running styles ..................................................................................................... 2
   2.2. Prediction of running performance ...................................................................... 3
   2.3. Running economy ............................................................................................... 4
       2.3.1. Vertical oscillation .................................................................................... 4
       2.3.2. Energy storage in muscles ........................................................................ 4
       2.3.3. Stride length/ step frequency .................................................................... 5
       2.3.4. Other factors ............................................................................................. 6
   2.4. Common errors in running and what injuries they can lead to .......................... 6
   2.5. Treating injuries by changing the running technique ........................................ 9
   2.6. Popular running techniques ............................................................................. 11
       2.6.1. Barefoot Running ...................................................................................... 11
       2.6.2. Pose Method® of Running ....................................................................... 12
       2.6.3. Chi Running® ......................................................................................... 13
       2.6.4. Good Form Running® ............................................................................. 13
       2.6.5. Evolution Running® ................................................................................ 14
   2.7. EZ Run Belt ...................................................................................................... 15

3. Aim .......................................................................................................................... 17

4. Methodology ............................................................................................................. 18
   4.1. Subjects ............................................................................................................. 18
       4.1.1. Subject 1 ................................................................................................. 18
       4.1.2. Subject 2 ................................................................................................. 18
       4.1.3. Subject 3 ................................................................................................. 18
       4.1.4. Subject 4 ................................................................................................. 18
4.1. Experimental design .......................................................... 19
4.2. Tests .................................................................................. 19
  4.2.1. Running economy ............................................................. 19
  4.2.2. Running Kinematics ....................................................... 20
4.3. Training intervention .......................................................... 20
4.4. Validity and reliability ....................................................... 20
4.5. Ethical considerations ....................................................... 21
5. Results .................................................................................. 23
  5.1. Results subject 1 ................................................................. 23
  5.2. Results subject 2 ................................................................. 26
  5.3. Results subject 3 ................................................................. 29
6. Discussion ............................................................................. 31
  6.1. General discussion ............................................................. 31
  6.2. Methodological discussion ............................................... 33
    6.2.1. Study design and subjects ........................................... 33
    6.2.2. Outcome measures .................................................... 34
7. Conclusion ............................................................................ 36
8. References ............................................................................ 37
Appendixes ............................................................................. 42
1. Introduction

Running causes high rates of injuries every year. Incidences of lower extremity running injuries between 19.4% and 79.3% have been reported yearly, and these statistics have stayed almost the same over the last 30 years regardless of the development that has occurred with running shoe design (van Gent, Siem, ven Middlekoop, van Os, Bierma-Zeinstra & Koes 2007).

Modification of running technique is one of the current trends to prevent, reduce and treat running injuries. There are now a lot of different kinematic models which describe running technique, which are marketed towards runners and coaches in a bid to make the correction of unfavorable running technique an easier undertaking. Some of those which have gained the most popularity among runners are Barefoot Running, Chi Running, Good Running Form, Evolution Running, and the Pose Method® (Robillard 2010). All these different running technique models share the same basic concept, something that is well accepted in the running and coaching world and that is that runners should eliminate heel strike and focus on forefoot landing. A number of studies have demonstrated a significant reduction of ground reaction forces when heel strike is eliminated (Squadrone & Gallozzi 2009, Romanov & Fletcher 2007, Lieberman, Venkadesan, Werbel, Daoud, D’Andrea, Davis, Mang Eni & Pitsiladis 2010).

It is suggested that shorter step length, forefoot landing, less vertical oscillation and shorter ground reaction time could be injury preventing factors (Daoud, Geissler, Wang, Saretsky, Daoud & Lieberman 2012, Heiderscheit, Chumanov, Michalski, Wille & Ryan 2011, Munro, Miller & Fuglevand 1987, Arendse, Noakes, Azevedo, Romanov, Schwellnus & Fletcher 2004, Fletcher, Bartlett & Romanov 2010). Interestingly, it seems that the same factors also result in the best running economy (Fletcher, Bartlett & Romanov 2010, Anderson 1996), except shorter stride length which seems to slightly increase oxygen consumption (Cavagna, Mantovani, Willems, & Musch 1997, Dallam, Wilber, Jadelis, Fletcher & Romanov 2005). However, this could be due to the short-term attempt to change the stride length from the self-selected one (Cavanagh & Williams 1982). Importantly, running economy is the best predictor of running performance (Conley & Krahenbuhl 1980).

EZ Run Belt (is read “easy run belt”) (JOE Sparks, 9101 Hufford Rd. in Perrysburg, Ohio, USA) is a tool which has been developed to “self-correct your running gait to a more efficient, high turnover, and injury resistant running style” (Sparks 2012). It is a belt worn
around the runner’s waist with elastic bands which act to shorten stride length, promote forefoot landing, shorten ground reaction time and lessen vertical oscillation. However, evidence supporting these claims based off controlled, intervention studies are limited. To date, only one study has used the EZ Run Belt as a tool for correcting running technique (Diebal, Gregory, Alitz & Gerber 2011). This study used the belt as a part of a case-series training program together with running drills to treat chronic compartment syndrome. Therefore, the present case-study will be the first to investigate the effects on both running kinematics and running economy of a 4-week training intervention in an ecological setting. By ecological setting, I mean that the subjects are using the belt on their own without interference from me as a researcher, and is meant to simulate how it would be if subjects had bought it on the internet and used it on their own as most people who buy a product like this usually do.

2. Literature review

2.1. Running styles

Three foot strike styles have been identified in studies of joggers, runners, and sprinters. The determination of style is based on which part of the foot strikes the ground first; the heel, the ball of the foot (from now called forefoot running), or the toes (with high heels from now called running on toes or toe running). Approximately 80% of runners strike the ground with heel first (Chan & Rudins 1994).

The foot strike plays a significant role when it comes to impact biomechanics. Derrick, Hamill and Caldwell (1997) observed that during heel striking, the shock sustained by the knee joint during impact increased with an increase in stride length. Cavanagh and LaFortune (1980) observed key differences in foot strike patterns and stride length between elite and recreational level runners. Elite runners took shorter strides and maintained the knee joint in flexion throughout the entire running cycle, and landed on the forefoot rather than the heel. Knee flexion throughout the run gait cycle allows the supporting leg to land on the ball of the foot, under the body, as opposed to heel striking which requires the knee joint to extend at landing past the vertical line that extends from the hip (Cavanagh & LaFortune 1980, Cavanagh, Pollock & Landa 1977). Given this, forefoot landing together with shorter stride length will lead to less impact on joints (especially the knee joint) and bones. Existence of a
relationship between foot strike, impact characteristics, and running injuries is widely discussed among scientists and coaches, and a recent study demonstrated that cross-country runners who habitually used a forefoot strike suffered about half as many injuries as those who were heel-strikers (Daoud, Geissler, Wang, Saretsky, Daoud & Lieberman 2012). It is unknown whether this relationship can be generalized to a more recreational running population or whether it might apply to runners who are actively attempting to modify their running form.

One clear difference between runners of varying ability and running style is the knee joint angle at landing. Experienced runners displayed a knee flexion angle at foot strike between 10° and 20° (Milliron & Cavanagh 1990) when measured at slower speeds (<4.0 m/sec) and an angle of 25° at faster speeds (> 4.0 m/sec) (Buczek & Cavanagh 1999, Cavanagh, Pollock & Landa 1977). The more the foot lands in front of the center of mass, the more the runner initiates contact with the ground through the heel. The closer the foot lands to the vertical line from the center of mass, the more the runner contacts the ground with the forefoot (Radin, Parker, Pugh, Steinberg, Paul & Rose 1993). When runners go from heel striking to forefoot landing, the knee flexion angle at landing increases and promote a greater ability to absorb the impact force at the knee joint (Cavanagh & Kram 1985).

2.2. Prediction of running performance

VO_{2}\text{max} is a well-documented predictor of how well a runner will perform in long distance running (Bassett & Howley 2000, Costill 1967, Foster 1983, Miyashita, Miura, Murase & Yamaji 1978). Its use as a performance predictor holds true when applied to groups of individuals with very different abilities and a wide range of VO_{2}\text{max}. However when comparing individuals with similar running abilities and aerobic fitness levels, VO_{2}\text{max} is not a good predictor of performance (Scott & Houmard 1994, Costill & Winrow 1979, Pollock 1977, Costill & Winrow 1970). In this case, running performance may be predicted by some other factor. It has been reported that the oxygen cost at a constant submaximal running speed differs a lot between subjects with similar VO_{2}\text{max} (Costill & Winrow 1970, Costill 1979, Noakes 1988). Conley and Krahenbuhl (1980) studied a group of 12 runners who had quite similar personal best times on 10-km (30:31 to 33:33) with VO_{2}\text{max} from 67 to 78 ml O_{2} \cdot kg^{-1} \cdot min^{-1}. They found that although VO_{2}\text{max} could not be used to predict the 10-km time, there was a correlation between the oxygen cost at three different submaximal speeds and the running time for 10-km. The subject with the lowest oxygen cost had the fastest time etc. (Conley and Krahenbuhl 1980). It therefore seems that running economy could be the best
factor for predicting long distance running performance and that as long as VO$_2$$_{max}$ is above a certain level; it plays a less critical role.

2.3. Running economy

Running economy is defined as the steady-state VO$_2$ for a given, submaximal running velocity and those who consume less oxygen at a given velocity are said to have better running economy (Quinn, Manley, Aziz, Padham & MacKenzie 2011). Running economy is influenced by many variables, both internal and external. Forefoot landing, less vertical oscillation and shorter ground reaction time results in the best running economy (Fletcher, Bartlett & Romanov 2010, Anderson 1996), while shorter stride length can slightly increase oxygen consumption (Cavagna et al. 1997, Dallam et al. 2005). As mentioned earlier, this could be due to the short-term attempt to change the stride length from the self-selected one (Cavanagh & Williams 1982). These elements are at the core of the Pose Method® of Running, and although no changes in running economy were measured after implementing the method in 16 recreational heel-strikers, a non-significant improvement of 24.7 seconds (4.3%) on a 2400m time trial (running) was reported (Fletcher, Romanov & Bartlett 2008). The Pose Method® is a system for teaching human movement, by determining key poses, and working with the laws of nature instead of against them. In running, this is achieved by accepting gravity as the primary force for forward movement instead of muscular energy (Romanov 2002).

2.3.1. Vertical oscillation

Uneconomical runners tend to have more vertical oscillation when they are running, compared to economical runners, resulting in greater energy cost (Miyashita et al. 1978). One of the early references on running technique and training by long-distance running guru, Arthur Newton (1935), discusses the energy cost of vertical oscillation during running. Newton, almost 80 years ago advised runners to use shorter strides, because as he described, the longer the strides, the more up-and-down movement the runners had, which was a waste of energy (Newton 1935).

2.3.2. Energy storage in muscles

Human legs contain spring-like tendons connected to short muscle fascicles that can efficiently produce force and also save the energetic cost of running. The Achilles tendon is
the most important of these tendons which can produce as much as 35% energy return (Alexander & Bennet-Clark 1977). The second most important energy returner is the plantar fascia which returns about 17% of the energy from the stance phase (Ker, Bennett, Bibby, Kester & Alexander 1987). Running is therefore often described as a bouncing locomotion pattern and the maximum effect is associated with shorter ground reaction time (McMahon & Cheng 1990).

### 2.3.3. Stride length/ step frequency

Runners naturally adopt a running style with a combination of step frequency and stride length which results in the lowest energy cost for any given speed (Cavanagh & Williams 1982). Energy cost increases when trying to adopt either faster or slower step frequency (Cavagna et al. 1997, Morgan, Martin, Craib, Caruso, Clifton & Hopewell 1994), but 20% of runners have been identified to over-stride (Morgan et al. 1994, Williams & Cavanagh 1987) and by reducing the stride length of these runners their performance improved (Morgan et al. 1994). Since most studies are completed over a short time period, the results could be different if the subjects allowed more time to adapt to the new step frequency (Cavanagh & Williams 1982).

Although runners seem to choose a step frequency which results in the lowest energy cost for any given speed (Cavanagh and Williams 1982), it seems like all elite distance runners have a step frequency above 180 steps per minute (Daniels 2005). Recreational runners on the other hand seem to lie between 150 and 170 steps per minute (Daniels 2005). Increased step frequency from self-selected one has been proven to reduce lower extremity loading during running (Hobara, Sato, Sakaguchi, Sato & Nakazawa 2012).

Two terms that are often misused and mixed are stride length and range of motion. The biomechanical essence of stride length has to do with the traveling distance of the general center of mass from one support to the other, where is the relationship between the point of support and the general center of mass is significant. The length of the running stride is defined as a distance between touching points of the same foot. Therefore the stride length is the distance between general center of mass on two sequent supports on the same foot, while range of motion only represents one thing: the space covered by the extremities due to the necessity to change support (Romanov 2002).
2.3.4. Other factors

When people begin exercising, economy improves (Robinson & Harmon 1941). Highly trained athletes also get more economical with more training (Conley, Krahenbuhl & Burkett 1981). So it seems like running in general improves running economy. Children are less economical than adults, but become more economical with age (Krahenbuhl & Williams 1992). Fatigue seems to play a role on running economy with increased energy cost during exercise at a constant speed (Helgerud 1994). Added weight on legs or feet affects running economy substantially. Adding 0.5 kg to each thigh or each foot increases the oxygen cost of running by 3.5% and 7.2% respectively (Martin 1985), which means choice and design of footwear is quite important in running.

2.4. Common errors in running and what injuries they can lead to

The creators of running techniques like the Pose Method® of running and Chi Running® state that pain only occurs because you are doing something wrong. They claim it is a warning signal that something is about to happen and that you have to change something to avoid “injuries” (Romanov 2002, Dreyer & Dreyer 2009).

There are a lot of common errors in running which can lead to injuries and the best known error is heel striking (fig. 1). That can potentially lead to knee pain, hip pain or lower back pain (Romanov 2002).

![Figure 1: Heel striking. Figure taken from Pose Method® of Running (Romanov 2002).](image)

Landing in front of the knee joint is another (fig. 2) and it can potentially lead to stress fractures or shin splints (Romanov 2002).
Overuse of the quad muscles (fig. 3) will often lead to muscle soreness and hamstring injuries (Romanov 2002).

Landing on the toes with high heels (fig. 4) often leads to shin splints, plantar fasciitis, Achilles tendonitis and calf muscle soreness (Romanov 2002).
Landing with stiff leg/ankle (locking of knee or/and ankle joint) as seen in figure 5 often leads to plantar fasciitis or Achilles tendonitis (Romanov 2002).

Active landing (fig. 6) is the last common error and it is often associated with muscle tension, plantar fasciitis and Achilles tendonitis (Romanov 2002).
All these errors and injury risks can be connected to earlier studies reporting that shorter step length, forefoot landing, less vertical oscillation and shorter ground reaction time could be injury preventing factors (Daoud et al. 2012, Heiderscheit et al. 2011, Munro, Millar & Fuglevand 1987, Arendse et al. 2004, Fletcher, Bartlett & Romanov 2010). Both Arendse et al. (2004) and Fletcher et al. (2010) reported more vertical oscillation when heel striking compared to Pose running. The step frequency is higher, step length is shorter and the eccentric loading on the knee joint is also reduced when Pose running (forefoot running) compared to heel striking (Arendse et al. 2004, Fletcher, Bartlett & Romanov 2010, Fletcher, Romanov & Bartlett 2008).

2.5. Treating injuries by changing the running technique

When runners seek medical advice for running-related injuries, they are often told to rest and avoid running for a period of time. That seems like an obvious cure for those who do not know better, and rest will most likely cure the symptoms, but more than likely not the cause of the injury. Often when the runner starts running again the lower limbs will be exposed to the same stress as before and they most likely develop the same injury again. The only injuries that require complete rest are those that make running impossible, like stress fractures. Runners are therefore advised to continue running, but only to the point where they experience discomfort (James, Bates & Osternig 1978).

To modify running technique is one of the current trends to prevent, reduce and treat running injuries. Commercialized running techniques which aim to eliminate heel strike and focus on forefoot landing such as Barefoot running, Chi Running®, Good Running Form®, Evolution Running®, and the Pose Method® have gained in popularity in the recent years (Robillard 2010). The reduction of ground reaction forces accompanying the elimination of heel strike...
has been demonstrated in a number of studies (Squadrone & Galllozi 2009, Romanov & Fletcher 2007, Lieberman et al. 2010), and there is evidence to suggest that shorter step length, forefoot landing, less vertical oscillation and shorter ground reaction time could all be injury preventing factors (Daoud et al. 2012, Heiderscheit et al. 2011, Munro, Millar & Fuglevand 1987, Arendse et al. 2004, Fletcher, Bartlett & Romanov 2010).

In a case study by Diebal and colleagues (2011), the effectiveness of running technique modification was examined. They wanted to see if it was possible to treat runners with compartment syndrome by changing their running technique to forefoot running. The two cases consisted of one male and one female, both 21 years old. They had both had compartment syndrome for a long time, one for four years and the other for seven months. Both subjects modified their running technique over a period of six weeks. They used different drills from the Pose Method® of running book and they used the EZ Run Belt to help change the running technique. (Diebal et al. 2011)

Kinematic and kinetic analyses revealed increased step frequency, while stride length, impulse and peak vertical ground reaction forces decreased. During the six weeks of intervention the subjects increased their running distance and speed free of symptoms of compartment syndrome. After seven months the subjects answered a follow-up questionnaire and one subject reported running distances up to 12.87 km pain-free, while the other subject reported running 6.44 km pain-free consistently three times a week. (Diebal et al. 2011)

Diebel and colleagues (2011) concluded that forefoot running instruction is potentially beneficial and advocated a conservative management approach to chronic exertional compartment syndrome in the form of forefoot running instruction. The authors emphasized that further research in the area is warranted to further explore the benefits of adopting a forefoot running technique for chronic exertional compartment syndrome as well as other musculoskeletal overuse complaints. (Diebal et al. 2011)

Although there is a common trend to prevent and treat running injuries by modifying running technique, a recent study by Ridge, Johnson, Mitchell, Hunter, Robinson, Rich and Brown (2013) has shown that runners interested in transitioning to minimalist running shoes, such as Vibram FiveFingers should transition very slowly and gradually in order to avoid potential stress injury in the foot. They did a study with two groups, one of the groups was randomly assigned to continue running as they had done before: same mileage, same shoes. The other group of runners were given a pair of Vibram Five Fingers barefoot-style shoes and asked to
begin incorporating some barefoot-like mileage into their runs, but gradually. They were told to wear the minimalist shoes for one mile during the first week of the study, two miles the second, three the third, and then as much as they liked, which is what the Vibram Web site recommended at the time of the study.

After 10 weeks, more than half of the runners wearing the minimalist shoes now showed early signs of bone injuries in their feet. Specifically, most had developed bone marrow edema, an accumulation of fluid, similar to what happens during bruising, in their foot bones. Two even had full stress fractures, one in the heel bone and one in the metatarsal. (Ridge 2013)

### 2.6. Popular running techniques

The commercialized running techniques such as Barefoot running, Chi Running®, Good Running Form®, Evolution Running®, and the Pose Method® described in detail below, but to summarize, the commonalities between them are:

- Forefoot landing
- Landing directly under the general center of mass
- Higher step frequency
- Shorter stride length
- Slightly bent knee at all time
- Good body posture
- Uses gravity as forward propulsion

#### 2.6.1. Barefoot Running

Lieberman (2013) say that there is no single “perfect running form.” Everyone’s body is different and no single technique could be best for everyone. Although he has some general tips for barefoot running:

A good landing should feel gentle, relaxed and compliant. You typically land on the ball of your foot towards the lateral side. After the front of your foot lands, let the heel down gradually, bringing the foot and lower leg to a gentle landing as you dorsiflex your ankle under the control of your calf muscles. It’s like when you land from a jump, flexing the hip,
knee and ankle. Again, the landing should feel soft, springy, and comfortable. It’s probably good to land with the foot nearly horizontal so you don’t have to work the calves too much.

Do not over-stride (land with your foot too far in front of your hips). Over-striding while forefoot striking requires you to point your toe more than necessary, adding stress to the calf muscles, Achilles tendon, and the arch of the foot. It often feels as if your feet are striking the ground beneath your hips. In this respect it feels like “running in place” (as runners sometimes do when waiting to cross a street). It is also similar to the way one’s feet land when skipping rope. (Lieberman 2013)

2.6.2. Pose Method® of Running

The Pose Method® is a system for teaching human movement, by determining key poses (fig. 1), and working with the laws of nature instead of against them. In running, this is achieved by accepting gravity as the primary force for forward movement instead of muscular energy (Romanov 2002).

![The running pose. Four views (Romanov 2002).](image)

The concept of Pose Method® of Running divides running into three elements: Pose-Fall-Pull (fig. 8). The pose describes the body alignment for running. The fall describes how the body “falls” forward due to gravity and the pull describes the only active action humans need to do while running, which is pull the foot from the ground. (Romanov 2002)
Figure 8: The concept of Pose Method® of Running (Romanov 2002).

The Pose Method® has been demonstrated to improve running performance without economy changes (Fletcher, Romanov & Bartlett 2008), reduce the eccentric loading on the knee (Arendse et al. 2004) and has also been used to demonstrate that runners do not push off the ground but fall forwards via a gravitational torque (Romanov & Fletcher 2007).

### 2.6.3. Chi Running®

Chi Running® is the revolutionary approach to injury-free running based on the movement principles of T’ai Chi. Similar to the mindful practices of Yoga, Pilates, and T’ai Chi, Chi Running teaches postural alignment, relaxation, and creation of meaningful communication between mind and body to help runners of all levels prevent and recover from injury, improve efficiency and performance, and enjoy running for a lifetime. (Dreyer & Dreyer 2009)

The main principles of ChiRunning® include (Dreyer & Dreyer 2009):

- correct alignment and posture
- landing with a forefoot strike
- using a "gravity-assisted" forward lean
- engaging core strength for propulsion, rather than leg strength
- maintaining a short stride and quick cadence
- connecting the mind and body

### 2.6.4. Good Form Running®

Good Form Running is based on the principle that running and walking are important skills to be learned, but that even today, they stand as two of the least studied, practiced, and perfected.
activities out there. They are also two of the most common injury-causing sports people engage in.

By practicing the four simple points (fig. 9) of Good Form Running, it is possible to reduce the unnecessary strain and torque caused by common running form and finds a way to run faster, easier and more injury free.

![Diagram of Good Form Running]

Figure 9: The concept Good Form Running® (Munson & Benedict 2012).

2.6.5. Evolution Running®
Evolution Running® is a system for teaching runners efficient and injury-reducing techniques and it consists of ten commandments (Mierke 2012) which are designed to be consciously thought about by the runner as they are running:

1. Land with your foot directly beneath your center of mass.
2. Never let your foot extend forward beyond the knee.
3. Land on the balls of your feet and keep the heel unweight throughout foot-strike.
4. Minimize contact time between your feet and the ground.
5. At any running speed, maintain the same high turnover rate (180 – 182 steps per minute or higher).
6. Maintain a straight line from the toes, through the hips, to the shoulders, but lean slightly forward with the hips and ribcage.
7. Maintain a constant, slightly-bent, knee angle from just before to just after foot-strike. Do not bend or straighten knee for propulsion.
8. Begin to pull leg back, from the hip with a constant knee angle, before foot-strike.
9. Use quick, light movements, not forceful ones, to propel forward
10. Immediately after the follow-through is completed, begin to drive the knee forward powerfully. As the knee drives forward, allow the foot to lag well behind during leg-recovery, using momentum, not muscular contractions, to raise the heel.

2.7. **EZ Run Belt**

In general, all these running methods advocate higher cadence, forefoot striking, shorter step length, less vertical oscillation and shorter ground reaction time. Correcting such kinematic variables is difficult for the average runner without highly skilled coach or instructor feedback. Hence the development of a product such as the EZ Run Belt (JOE Sparks, 9101 Hufford Rd. in Perrysburg, Ohio, USA), seen below in fig. 10. This product has been designed to “self-correct your running gait to a more efficient, high turnover, and injury resistant running style” (Sparks 2012), and ultimately improve performance, without the need for coaches or instructor feedback.
Figure 10: EZ Run Belt (Sparks 2012).

The package of EZ Run Belt contains of a waist belt, ankle straps and tubing. The tubing attaches behind the waist belt and ankle straps, to gently remind the runner to pull their leg up under their body. Every time the runner tries to extend their leg in front of their body, the tension on the tubing will increase, forcing them to pull their leg up under their body. (Sparks 2012)
3. **Aim**

The purpose of the study is to explore within a case-study design if training with the EZ Run Belt in an ecological setting changes running kinematics and if it affects running economy.

Specific aims of the case studies are as follows:

- Does training with EZ running belt change running kinematics (stride length, step frequency, foot strike pattern, range of motion)?
- Does training with EZ Run Belt affect running economy?
4. Methodology

A case study design has been chosen to answer the aim of this study. Since there have not been any studies testing the efficacy of the EZ Run Belt on its own, a case study gave the possibility to look at a greater depth at subjects with different running techniques and to assess in greater detail how the belt might affect the different running techniques compared to other experimental designs. This qualitative approach is valuable because it can give indications of which kind of running technique might benefit more from using the belt and is advantageous due to its ability to go more in depth with single phenomenon (Yin 2009).

4.1. Subjects

Information about the study with a request to participate was sent to about 20 people which I knew did regular running training, both male and female. Of those, only four wanted to participate. The inclusion criteria were that the subjects regularly ran at least two times per week. The four subjects had different running background, but all were based in Falun. Only two of the subjects completed the study (subject 1 and 2). A letter was sent to the subjects with information about the study (Appendix 1). The athletes gave their written in-formed consent to participate in the study (Appendix 2). The study design was approved by the Research Ethics Board at Dalarna University.

4.1.1. Subject 1

Subject 1 was a 59 year old female (166.5 cm, 77 kg). She has been a recreational runner almost her whole life, competing both in half marathons and orienteering. Over the last years she has although had some injury problems, and as a result has run less than before.

4.1.2. Subject 2

Subject 2 was a 29 year old male (181 cm, 81 kg). He has been a former elite orienteer, but has now retired due to injuries. He is still doing some recreational running and still does some street races and orienteering competitions.

4.1.3. Subject 3

Subject 3 was a 25 year old male (177 cm, 67 kg). He is an elite orienteer, with an average running mileage around 150 km per week on his training schedule. He has a history with some typical running related injuries like Achilles tendonitis and runners knee.

4.1.4. Subject 4
Subject 4 was a 24 year old female. She is an elite mountain bike orienteer, and most of her training is cycling, but she also does some running and competitive orienteering. No height or weight were measured as she got injured before the first test occasion.

4.1. Experimental design
Subjects visited LIVI test laboratory on two different test sessions. The study design consisted of one pre-test followed by a 4-week training intervention and a post-test and it was administered as an case study.

4.2. Tests
The following tests were conducted both before and after the training intervention.

4.2.1. Running economy
The subjects ran an economy test on a treadmill (cos10198, h/p/cosmos sports & medical gmbh, Nussdorf-Traunstein, Germany) at two different self-selected submaximal paces. Tests took place at the same time of day for both the pre- and post-test. The subjects were required to maintain a similar diet, sleep pattern, and training routine before each test session. The subjects did a warm up on the treadmill for 5 min at 1% incline (to simulate flat running), and then they ran two 6-min bouts at self-selected speeds, with the second bout at a higher speed than the first. Both bouts were run on a 1% incline and without rest between the two bouts. The subjects decided their three different paces before the test started. Total time on the treadmill for all subjects was 17 minutes.

Submaximal running economy was defined by the average VO$_2$ ml/kg/km recorded over the last minute of each 6-min bout conducted with the treadmill at 1% incline. Ten-second gas collection data were averaged over the last minute. The VO$_2$ was measured by open-circuit indirect calorimetric using an Oxycon Pro apparatus (Jaeger GmbH, Hoechberg, Germany). Before each test, the gas analysers were calibrated automatically with gas mixture. The heart rate was measured by heart rate monitors (Polar S610, Kempele, Finland).

Morgan, Martin, Baldini, and Krahenbuhl (1990) investigated 16 male subjects who completed two 10-minute running economy tests at the same time of the day within a 4-day period wearing the same pair of shoes. The intra-individual coefficients for variation in running economy was 1.6%. Another study by Pereira, Freedson and Maliszewski (1994) reported similar coefficients for variation with 1.5% for running economy in five trained male runners by careful control of extrinsic factors such as time of testing, diet, footwear and
relative workload. Since the subject in this study did both pre- and post-tests at the same time of the day with the same footwear and were encouraged to have a similar diet before each test occasion one can assume that the variation should be around 1.5% also in this study.

4.2.2. Running Kinematics
During the economy test the subjects were filmed from the lateral view with a Panasonic NV-MX500EG camera (Panasonic Corporation, Osaka, Japan) to analyze the running kinematics. The stride frequency was counted over a random minute in each of the two 6 minute bouts and stride length were calculated from the stride frequency and the speed on the treadmill\(SL = \frac{m}{s}/Hz\).

The foot-strike pattern and the range of motion were determined by using Kinovea video analysis software (Creative Commons, Mountain View, USA). During the step counting frame by frame, the step was analyzed to be consistent and a random step was chosen for foot strike and range of motion analysis. Range of motion represents the space covered by the extremities at foot strike and is measured between the ankles.

4.3. Training intervention
Each subject received an EZ Run Belt, an explanation and demonstration of its use by the researcher. The participants used the belt for a part of their normal running sessions, up to half of their total time running, with a minimum of 10 minutes per session. It was used at least two times a week or a minimum of 20 minutes of running time. In this way, individual differences in training volume could be taken into account, whilst maintaining a minimum “dosage” of running time with the belt. The subjects were encouraged to not wear big cushioned shoes during the intervention since these make it difficult to change running technique. The training intervention went on for a period of 4 weeks.

Since the EZ Run Belt is a product that can be bought online and people are supposed to use it by themselves, without assistance from a coach or instructor and is designed to work as a technique coach on its own, this study was done in an ecological setting without any input, feedback or interference from the researcher during the intervention. The subjects could contact the researcher with any questions regarding the study or the belt.

4.4. Validity and reliability
For a test to be valid it has to measure something that gives answer to the aim, and if the test gives the same results when it is done several times the test is reliable (Thomas, Nelson &
Silverman 2005). The terms Reliability and Validity are essential criterion for quality in quantitative study designs; while in qualitative study designs the terms Credibility, Neutrality or Confirm-ability, Consistency or Dependability and Applicability or Transferability are to be the essential criteria for quality (Lincoln & Guba 1985).

The ability to generalize findings to wider groups and circumstances is one of the most common tests of validity for quantitative research, but Patton (2002) states generalizability as one of the criteria for quality case studies depending on the case selected and studied.

The tests chosen in this study are similar to what have been done in other similar studies, and are well proven tests for measuring running economy and analyzing running kinematics. The equipment was calibrated before each test to get the most reliable results. The tests were conducted at the same time of the day for each subject at both pre- and post-test to minimize the physiological variation during the day. The subjects were told to eat the same the last 24 hours before each of their two tests, also to avoid physiological variations due to different diet. At the tests the subjects were told to use the same shoes for both tests since wearing different shoes could affect the results.

4.5. Ethical considerations

There are two issues which require consideration from an ethical standpoint in this study. Firstly, all video recordings made of the subjects and personal information will be handled confidentially during the study and will only be used for the purposes of this study. The films will be archived in a secure manner and deleted when the study is completed. Secondly, since the subjects may change their technique, the risk of getting an injury may be increased. No relevant studies on injuries as a result of changing running technique were found. Changing technique is commonly done through coach feedback and the purpose is to minimize risk of long term injury and improving performance. Coaches from track and field normally manage short term injury risk by introducing new technique using different drills for a total time of approximately 20 minutes per training session. This normally takes place before the athletes are fatigued to decrease the chance of injury through impaired neuromuscular coordination and mental concentration. In this study runners will be using the belt for a minimum of 10 minutes per session and will be recommended to use it in the beginning of their sessions. Although there is a high possibility of the development of minor muscle soreness at the start
of the intervention period, more serious injuries such as aggravation of tendonitis complaints
due to changes in force distribution may occur but are unlikely. The subjects are strictly told
to abort their training sessions if discomfort occurs. They are also free to abandon the study
whenever they want without any questions from the researcher. Subjects who have been told
by their doctor to refrain from running will be excluded from this study. Although the belt
restricts movement as it is designed to do, it is comfortable and easy to use and does not pose
any increased risk of falling or tripping.
5. Results

Subject 3 got injured at the end of his third week at a hard interval session during the intervention and were not able to do the post-test. Results from the pre-test have been included because some interesting observations were seen in his pre-test compared to other elite runners.

Subject 4 unfortunately got injured after a bad crash on skis the day before the pre-test and could therefore not participate in the study.

5.1. Results subject 1

Subject 1 completed the minimum amount of running. She ran two times a week, for 20-30 minutes each time and wore the belt for the first 10 minutes of each session. She found running with the belt a bit awkward in the beginning, and she did not like it much, but she also said she could feel it changed her running stride. Since she had run in one specific way for 60 years it felt uncomfortable to run in a different way in the beginning. She felt that it got a bit better after some sessions.

Subject 1 increased her stride frequency, heart rate and VO₂ consumption (16% change) and decreased the stride length at 8 km/h during the training intervention as seen in table 1.

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>V'O₂ ml/kg/km</td>
<td>208.6</td>
<td>242.0</td>
</tr>
<tr>
<td>Heart rate per minute</td>
<td>152</td>
<td>163</td>
</tr>
<tr>
<td>Steps per minute</td>
<td>167</td>
<td>179</td>
</tr>
<tr>
<td>Stride length in centimeters</td>
<td>80</td>
<td>74</td>
</tr>
</tbody>
</table>

The table shows how running kinematics and work economy have changed during the 4 week training intervention at 8 km/h.

The foot strike changed from a clear heel-strike to a more forefoot landing at 8 km/h during the training intervention as seen in figure 11.
There was less range of motion at 8 km/h after the training intervention as seen in figure 12.

Subject 1 increased her stride frequency, heart rate and VO$_2$ consumption (5% change) and decreased the stride length at 9.5 km/h during the training intervention as seen in table 2.

Table 2. Changes in running kinematics and work economy at 9.5 km/h

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>V'O2 ml/kg/km</td>
<td>210.0</td>
<td>220.7</td>
</tr>
<tr>
<td>Heart rate per minute</td>
<td>166</td>
<td>178</td>
</tr>
<tr>
<td>Steps per minute</td>
<td>176</td>
<td>185</td>
</tr>
<tr>
<td>Stride length in centimeters</td>
<td>90</td>
<td>86</td>
</tr>
</tbody>
</table>

The table shows how running kinematics and work economy have changed during the 4 week training intervention at 9.5 km/h.

The foot strike changed from a clear heel-strike to a more forefoot landing at 9.5 km/h during the training intervention as seen in figure 13.
There was less range of motion at 9.5 km/h after the training intervention as seen in figure 14. After training with the belt for 4 weeks the heel-strike was eliminated and the subject changed to a more forefoot strike. That will decrease the risk for knee pain, hip pain and lower back pain (Romanov 2002). Although heel-strike was eliminated the subject was still landing in front of the general center of mass which gives a braking effect.

The stride frequency increased to 179 or more steps per minute. Analysis of distance runners have shown that elite runners have step frequency above 180 steps per minute while recreational runners have between 150 and 170 steps per minute (Daniels 2005). Higher step frequency together with shorter stride length is also reported to give less eccentric loading on the knee joint (Arendse et al. 2004, Fletcher Bartlett & Romanov 2010, Fletcher, Romanov & Bartlett 2008).
Both the oxygen cost and the heart rate increased after adopting the new running technique with higher step frequency which is considered normal, and could have been the case also if the step frequency had been decreased (Cavagna et al. 1997, Morgan et al. 1994).

5.2. Results subject 2

Subject 2 used the belt 3-4 times per week of varying length and often more than once per session. For example 5 minute on, 5 minute off, 5 minutes on etc. He did not find it awkward to run with the belt, but directly after taking it off noticed that his hamstrings felt really weird. He found it difficult to explain the feeling, but it only occurred during the first 30 seconds after taking off the belt. He could not feel any changes in running technique while running with the belt and he did not think he had changed anything during the intervention.

Subject 2 had very small changes but a small increase in stride frequency, heart rate and VO$_2$ consumption and a decrease in the stride length at 12 km/h during the training intervention as seen in table 3.

**Table 3.** Changes in running kinematics and work economy at 12 km/h

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO$_2$ ml/kg/km</td>
<td>212.1</td>
<td>214.5</td>
</tr>
<tr>
<td>Heart rate per minute</td>
<td>184</td>
<td>187</td>
</tr>
<tr>
<td>Steps per minute</td>
<td>174</td>
<td>178</td>
</tr>
<tr>
<td>Stride length in centimeters</td>
<td>115</td>
<td>112</td>
</tr>
</tbody>
</table>

The table shows how running kinematics and work economy changed during the 4 week training intervention at 12 km/h.

The foot strike changed from a heel-strike to a more forefoot landing at 12 km/h during the training intervention as seen in figure 15.

Figure 15: Changes in foot strike pattern at 12 km/h
There is less range of motion at 12 km/h after the training intervention as seen in figure 16.

![Figure 16: Changes in range of motion at 12 km/h](image)

Subject 2 increased his stride frequency, heart rate and VO$_2$ consumption slightly and decreased the stride length slightly at 14 km/h during the training intervention as seen in table 4. The changes are still very small.

**Table 4. Changes in running kinematics and work economy at 14 km/h**

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO$_2$ ml/kg/km</td>
<td>205.6</td>
<td>211.1</td>
</tr>
<tr>
<td>Heart rate per minute</td>
<td>192</td>
<td>194</td>
</tr>
<tr>
<td>Steps per minute</td>
<td>182</td>
<td>184</td>
</tr>
<tr>
<td>Stride length in centimeters</td>
<td>128</td>
<td>127</td>
</tr>
</tbody>
</table>

The table shows how running kinematics and work economy changed during the 4 week training intervention at 14 km/h.

The foot strike changed from a slight heel-strike to a more forefoot landing at 14 km/h during the training intervention as seen in figure 17.
Figure 17: Changes in foot strike pattern at 14 km/h

There was slightly less range of motion at 14 km/h after the training intervention as seen in figure 18.

Figure 18: Changes in range of motion at 14 km/h

After training with the belt for 4 weeks the heel-strike was more or less eliminated and the subject changed to a more forefoot strike. As discussed previously, this decreases the risk for knee pain, hip pain and lower back pain (Romanov 2002). Although similarly to subject 1, this subject was also still landing in front of the general center of mass which gives a braking effect.

The stride frequency did not change much, but increased slightly to 178 or more steps per minute. Small changes also regarding the oxygen cost and heart rate but they are so small that they could be due to natural small errors of the measurement.
5.3. Results subject 3

Subject 3 used the belt 2-4 times per week, mostly during warm-up for the first three weeks. Then he suddenly got a muscle rupture in one of his calves during a hard training session. Due to that he had to withdraw from the study. Although he got injured during the intervention he said he really liked training with the EZ Run Belt. He said it felt like it had some effect on step frequency and that he felt like he got this foot more up under his hip.

His running economy and running kinematics at 15 km/h can be seen in table 5.

<table>
<thead>
<tr>
<th>Table 5. Running kinematics and work economy at 15 km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>V’O2 ml/kg/km</td>
</tr>
<tr>
<td>219.7</td>
</tr>
<tr>
<td>Heart rate per minute</td>
</tr>
<tr>
<td>Steps per minute</td>
</tr>
<tr>
<td>Stride length in centimeters</td>
</tr>
</tbody>
</table>

The table shows the initial running kinematics and work economy at 15 km/h.

Subject 3 had a forefoot landing, and prepare the landing quite high up in the air as seen in figure 19 which can indicate some vertical oscillation.

Figure 19: Foot strike pattern at 15 km/h

His running economy and running kinematics at 17 km/h can be seen in table 6.

<table>
<thead>
<tr>
<th>Table 6. Running kinematics and work economy at 17 km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>V’O2 ml/kg/km</td>
</tr>
<tr>
<td>220.3</td>
</tr>
<tr>
<td>Heart rate per minute</td>
</tr>
<tr>
<td>Steps per minute</td>
</tr>
<tr>
<td>Stride length in centimeters</td>
</tr>
</tbody>
</table>

The table shows how running kinematics and work economy at 17 km/h.
At 17 km/h subject 3 showed a similar forefoot landing and higher landing preparation (fig 20) as when running at 15 km/h.

Figure 20: Foot strike pattern at 17 km/h

Subject 3 was a forefoot runner, but his landing was ahead of his general center of mass and also in front of his knee joint. This increases the risk for stress fractures and shin splints fig. 2 (Romanov 2002).

The stride frequency for subject 3 was very low compared to other elite runners. Elite values normally exceed 180 steps per minute (Daniels 2005). Subject 3 had a stride frequency of 153 and 155 steps per minute on the two different speeds which is considered extremely low. That can be compared to the low range of recreational runners which are lying between 150 and 170 steps per minute (Daniels 2005). Higher step frequency together with shorter stride length is reported to give less eccentric loading on the knee joint (Arendse et al. 2004, Fletcher Bartlett & Romanov 2010, Fletcher, Romanov & Bartlett 2008). Although a more in depth analysis of his running style and history is warranted, consideration of step frequency may be of value for reducing lower extremity loading (Hobara et al. 2012) in this case given the occasional knee problems he reported.
6. Discussion

6.1. General discussion

In general, both subjects who completed the study responded in a similar way to training with the EZ Run Belt, although the changes are bigger for subject 1 than for subject 2. Both subjects eliminated heel-strike, increased step frequency, heart rate and oxygen consumption and decreased stride-length and range of motion. The changes are also quite similar at both speeds for both subjects. This gives an indication that the EZ Run Belt may be effective, and consistent in promoting an injury resistant running style through gait correction, increasing efficiency and ultimately improve performance, without the need for coaches or instructor feedback.

Before participating in this study, both subject 1 and subject 2 were typical heel-strikers (subject 1 slightly more than subject 2) as 80% of the running population is (Chan & Rudins 1994). Heel-striking increases the risk for knee pain, hip pain and lower back pain fig. 1 (Romanov 2002) and is also associated with more vertical oscillation than Pose running (forefoot landing) (Arendse et al. 2004, Fletcher, Bartlett & Romanov 2010). The more the foot lands in front of the center of mass, the more the runner initiates contact with the ground at the heel. The closer the foot lands to the vertical line from the center of mass, the more the runner contacts the ground with the ball of the foot (Radin et al. 1993). When runners modify their foot strike pattern from heel striking to forefoot landing, the knee flexion angle at landing increases and promote a greater ability to absorb the impact force at the knee joint (Cavanagh & Kram 1985). Knee flexion throughout the run gait cycle allows the support leg to land on the forefoot, under the body, as opposed to heel striking which requires the knee joint to extend at landing past the vertical line that extends from the hip (Cavanagh & LaFortune 1980, Cavanagh, Pollock & Landa 1977). Observations show that both the subjects in this study have eliminated heel-strike and since heel-striking doubles the chances of injuries compared to a forefoot strike (Daoud et al. 2012) this is a really positive effect. It may also explain the injury problems both subject 1 and 2 have had earlier, since both of them were heel-strikers before the intervention.

Both subjects have also increased their step frequency and shortened their stride length which is reported to give less eccentric loading on the knee joint (Arendse et al. 2004, Fletcher
Bartlett & Romanov 2010, Fletcher, Romanov & Bartlett 2008) and would also most likely decrease the possibilities for knee pain.

Since this study did not assess running performance, no inferences can be made directly about performance. However, work economy has been shown to be a good predictor of performance in running (Conley & Krahenbuhl 1980) and since work economy of both subjects decreased, it could be expected that running performance would also have decreased. This could be due to adopting a higher step frequency and shorter stride length over a short period of time, which is proven to increase oxygen consumption (Cavagna et al. 1997, Dallam et al. 2005). This is likely to return to normal after a period of time habituating to new running technique. It would therefore be interesting to do a following up test in 6 months to see if the new technique, step frequency and stride length are maintained, and to see if there is a recovery in running economy. The changes for subject 2 are so small that they could be due to the natural small errors of the measurement, but for subject 1 which has a change in running economy by 16% at 8 km/h it is different. That is a really large change and cannot be explained by small natural errors of measurement.

Although heel-strike was eliminated through the use of the belt in this study, it did not seem to effect over-striding. After 4 weeks of intervention, both subjects still landed in front of their general center of mass. Both runners used the belt during regular running sessions and no running drills were performed while wearing the belt. Changes in range of motion may be more easily achieved through the use of running drills, when subjects are more aware of what they actually are trying to change. Diebal and colleagues (2011) observed larger increases in step frequency in their case studies when they used the EZ Run Belt in combination with running drills than achieved in this study. They got an increase in step frequency from 160-202 steps per minute and a decrease in stride length from 120cm-102cm (Diebal et al. 2011).

The foot-strike pattern of subject 3 prior to the training intervention was quite similar to subject 1 and 2 after the training intervention. However, due to a calf injury subject 3 had to withdraw from the study. Any changes to the foot strike pattern of subject 3 had he completed the training intervention are difficult to predict, but given he had a more forefoot strike pattern to start with, changes may have been minimal. Although he had a very low step frequency prior to the training intervention it would have been interesting to observe how this responded to training. Since both the other subjects increased their step frequency one could predict that subject 3 would have done the same.
He did not incur the injury while he was using the belt, and it is unclear if the injury developed from an alteration of his running technique as a result of using the belt or from taking part in the study. Elite runners are often on the edge of what the body can handle and injuries are not uncommon among elite runners. From observing this subject running at the start of the intervention it seemed that he ran with a large amount of vertical oscillation, with quite a lot range of motion in his lower extremities and he was landing in front of both his general center of mass and in front of his knee joint as seen in fig. 19 and 20. These running characteristics can be the reasons for his previous and present injuries.

6.2. Methodological discussion

6.2.1. Study design and subjects

A case study in an ecological setting was chosen since the efficacy of the EZ Run belt not has been tested independently from the instructing or coaching situation before. Media such as the internet, TV and newspapers are the marketing forums for many different products that claim to improve consumers’ health and fitness capabilities in very short periods of time (for example, TV shop training products). These products all claim to be very easy to use and highly effective, but very few of the products are independently tested according to high-quality research-founded criteria. Altering technique in sport is normally the domain of highly skilled coaches and difficult to achieve without discipline and feedback. The idea that a simple belt with elastic bands attached to a runner’s ankles, purchasable on the internet and used without the need for a coach or instructor, could alter running technique and reduce injury risk is very attractive to a great proportion of the population. It was therefore the aim of this study to see if this product could alter running kinematics and economy without the input from an instructor or coach. It appears that although the belt is effective, it may be more effective when used under guidance of coaches/instructors or with defined drills.

From a biomechanical view, the design of the belt has some merits in terms of potential effects it may have on running kinematics. The rubber band should restrict some leg movement during running, which could give the effects claimed by the manufacturer.

The advantage of a case study design is that it is possible to get more detailed indications of how the product can impact runners with different running styles, while with a quantitative approach all subjects would have needed to have the same running style. In the two cases presented here, the EZ Run Belt facilitated changes from heel-striking to a less injury-prone
forefoot strike pattern. Although changes in other outcomes (e.g. knee angles) were unclear, in part due to technological limitations, these results warrant an up-scaled intervention study on a larger group of heel-strikers. This would give the possibility to determine any statistical and practical worthwhile changes in a larger group. Also of interest would be the changes in running economy over a longer period of time, to determine if this returns to basal levels as the subjects become more familiarized with the newly adopted running technique.

It was difficult to recruit subjects to take part in this study. It seems that runners, and in particular elite runners, are generally skeptical about changing their running technique. Most elite runners have coaches so the need for this kind of product may not be the same as for recreational runners, who most often do not have their own coaches. Of interest would be to observe what kind of effects training with a product like the EZ Run Belt would have on elite runners, with and without concurrent coaching.

In this study, a 4-week training intervention with the EZ Run belt resulted in changes in running technique. The new technique the subjects adopted seemed to be consistent during the test, but since the test was quite short it is not possible to say if the subjects would have managed to maintain the new technique for a longer time. But since the subjects seemed quite consistent during the test I would think the subject would maintain the technique also for longer runs. A recent, similar study by Warne and Warrington (2012) showing significant changes in running economy from using Vibram Five Fingers also utilized a 4-week training intervention. It is possible that an intervention period of even less time is sufficient to bring about changes in running technique, given that technique has been reported to change from heel-striking to forefoot running in as little as 15 minutes and one week from heel striking to Pose® running (Arendse et al. 2004).

Adherence to the intervention in studies such as this is difficult to control. Moreover, the aim of determining if the belt was able to act as a technique coach on its own, in an ecological setting set the boundaries for allowing the subjects to have a greater level of freedom on their utilization of the belt during the intervention period.

6.2.2. Outcome measures

The chosen tests were valid for the purpose of the study. The use of a treadmill allowed comparisons at the same speeds before and after the intervention. That together with testing at the same time of the day, using the same footwear, having the same diet should give good reliability on the tests. The reliability is not measured in this study, but compared to the
reliability study from for example Pereira et al. (1994) the variations on the running economy measures should only be around 1.5%. Additional tests could have provided further information, however equipment limitations (e.g. low capture rate of the camera used) and availability posed some limitations to the outcomes measured.


7. Conclusion

The EZ Run Belt could be a good tool for heel-strikers as it eliminated heel-strike and helped with changing the stride into a more fore foot strike in the two case studies presented. It may also help increase step frequency and decrease stride length. These positive changes in foot strike pattern, step frequency and stride length are all injury preventing factors. However, small increases in oxygen consumption which result in decreased work economy were also observed, indicating the need for more research to see if this is consistent for larger groups and if these changes are maintained over a longer period of time.
8. References


Appendixes

Appendix 1 - Information letter

Information about the study: Test of EZ Running Belt.

You are hereby asked to participate in this study.

One issue which is very important for runners is to minimize the risk of injuries and improve both running performance and running economy. Research has shown that optimal running technique involves eliminating heel strike and focusing on forefoot landing. From previous studies it seems that shorter step length, forefoot landing, less vertical oscillation and shorter ground reaction time could be injury preventing factors. The same factors seem to be important also for running economy.

There is a product called the EZ Run Belt (seen in picture below) which is developed to “self-correct your running gait to a more efficient, high turnover, and injury resistant running style”. You will train with this product to see how it affects running kinematics and running economy.

The study will be a case study and will include 1-4 subjects with suboptimal running technique. If you have an injury such that you have received medical advice to refrain from running, or that you suffer from pain as a result of running and training, you will be excluded from the study.

You will each get an EZ Run Belt and get an explanation and demonstration by me. You will use the belt for a part of your normal running sessions, preferably in the beginning of the session, and up to half the total time running, with a minimum of 10 minutes per session. It should be used to running at least two times a week or a minimum of 20 minutes. In this way, individual differences in training volume can be taken into account, whilst maintaining a minimum “dosage” of running time with the belt (you should stop running if you experience discomfort). You should not wear big cushioned shoes during the intervention since they make it difficult to change the running technique. The training intervention will go over a period of 4-5 weeks. You will do all your training by yourself, and you will be required to record all training during the 4-5 weeks. I will be in weekly contact with you to discuss your progress. Of course you may contact me anytime during the study.
There will be two test occasions with one before and one after the training intervention. Running kinematics (stride frequency, stride length, contact time and air time) will be measured on an indoor running track. Data will be collected from a 30 m run with flying start. You will also be filmed to observe your foot strike pattern.

You will run the economy test on a treadmill at different submaximal speeds. You will first warm up at a self-selected pace for 5 min at 1% grade, and then you will run to 6 min bouts at two different submaximal self-selected velocities.

Submaximal running economy will be defined by the average VO2 (l·min⁻¹, ml·kg⁻¹·min⁻¹) recorded over the final 2 min of each 6-min bout conducted with the treadmill at 1% grade (to simulate running flat).

You will agree on which dates and time your test will be done and we want you not to do any hard training above aerobic threshold or maximum strength training during the two days prior to the tests. Tests will take place at the same time of day at both pre- and post-test. You are required to maintain a similar diet, sleep pattern, and training routine before each test session. The study will be published as a master thesis at Dalarna University and GIH and the study is research ethically reviewed by the Research Ethics Board at Dalarna University.

The collected data will be coded so it is not identifiable to you as an individual and stored in a secure manner and the video files will be deleted when the study is finished. No names or identifiable characteristics will be published in the study.

Your participation in the study is voluntary and you can at any time choose to end your participation in the study without giving a reason.

Further information will be given by the responsible below

Kim André Sveen, h09kasve@du.se  +47 41929191

Supervisor: Emma Hawke, ehw@du.se

Approved by the Research Ethics board at Dalarna University (05.02.2013)
Appendix 2- Consent form

Consent form

The undersigned has received the written research information and have had the opportunity to ask additional questions and have them answered.

Consent by the signature provided to participating in the study and treatment of personal data.

The consent also includes that the scientists have access to the information and analyze the collected test data from the participants.

Date: __________________

Signature: ___________________________________________________

Name: _________________________________________________________