NATURAL POSTURE RUNNING:

A Biomechanical and Physiological Pilot Study

May 13, 2006

A RESEARCH REPORT PREPARED BY:

Reed Ferber Ph.D., CAT(C)
www.runninginjuryclinic.com

runninginjuryclinic

Calvin Zaryski MKin, PLFC
www.criticalspeed.com

criticalspeed.com
ACTIVE LIFESTYLE COACHING

Gwyneth DeVries, MD

BACKGROUND

Natural Posture Running (NPR) is a new concept in running based on the evolution of humans as endurance runners over the past two million years. Some of the evolutionary features which humans have developed include longer tendons acting as springs in the ankle and foot and shorter toes and longer legs for more speed. In addition, larger joint surfaces in the lower body act as shock absorbers and well-developed core stability muscles stabilize the trunk. Finally, independently moving pelvis and shoulder girdles, shorter lighter forearms which speed up the arm swing and help counterbalance the lower body, and the ability to sweat with an estimated 3 million sweat glands are all advantageous to endurance running. NPR optimizes the use of these natural evolutionary characteristics, coupled with the law of gravity, to improve running economy, speed, and endurance.

Other running methods exist which also claim to improve running performance including Chi Running, the Pose technique, and the Alexander method of running. However, very few scientific investigations have been performed to validate their claims. Therefore, the purpose of this study is to examine physiological and biomechanical changes prior to and following a NPR running training program.

It was hypothesized that following the training program, runners will demonstrate greater physiological running economy. It is also hypothesized that the runners will exhibit a mid-foot strike pattern with less ankle flexion at heel strike, a greater forward trunk lean at midstance, and an overall more flexed lower extremity posture with greater knee and hip flexion at heel strike and midstance.

EXPERIMENTAL METHODOLOGY

Subjects

Six adult running subjects (3 female and 3 male) were recruited to take part in this pilot study. All subjects were able to complete 30 minutes of comfortable running prior to taking part in the study and no subjects were suffering any musculoskeletal injury at the time of the data collections.

The runners were tested prior to and following a 5 week training period where they were taught the NPR running method by coaches trained in this technique.

Procedures and Data Collection

For the physiological variables, each subject's sub-maximal heart rate was estimated based on the equation of 180 – age. Some subjects testing heart rates were modified to allow them to run at a steady pace and remain

comfortable. These testing heart rates were recorded and subjects were expected to run at the same heart rate during their post-testing session. The Aerobic Economy Running test was conducted on a 200m indoor running track in a controlled environment. A Polar 610 heart rate monitor was used to control their running intensity by monitoring heart rate. After a short warm up, the subjects were instructed to run at their sub maximal heart rate for 10 laps (2 km). Lap splits were recorded as well as their actual heart rates after each lap. If the actual lap heart rates were higher or lower than the predetermined value, a mathematical formula was used to baseline the values for comparison purposes. Running economy was determined as the time it took each subject to complete the 10 laps at the same sub-maximal heart rate prior to and following the NPR testing program.

Biomechanical variables were measured by two-dimensional video analysis while subjects ran at a comfortable pace on an indoor track. A video camera was placed 3 metres from the side of the track. Five kinematic reflective markers were placed on the skin (see Figure 1) overlying the base of the fifth metatarsal (toe of the shoe), lateral malleolus (ankle bone), lateral condyle of the femur (side of knee), greater trochanter of the femur (hip bone), and acromion process of the scapula (tip of shoulder). A total of five trails for each subject were used for analysis.

Data Analysis

Physiological variables of interest included running economy as estimated by the time to complete 10 laps (2 km) at a pre-determined sub-maximal heart rate.

Biomechanical variables of interest at heel strike included foot angle relative to the horizontal and ankle, knee, and hip joint angles. Biomechanical variables of interest at midstance (foot flat) included ankle, knee, and hip joint angles and trunk lean relative to the vertical (see Figure 1). Variables of interest were calculated using a custom written MATLAB (The MathWorks, Inc., Natick, MA, USA) computer program using the video kinematic data.

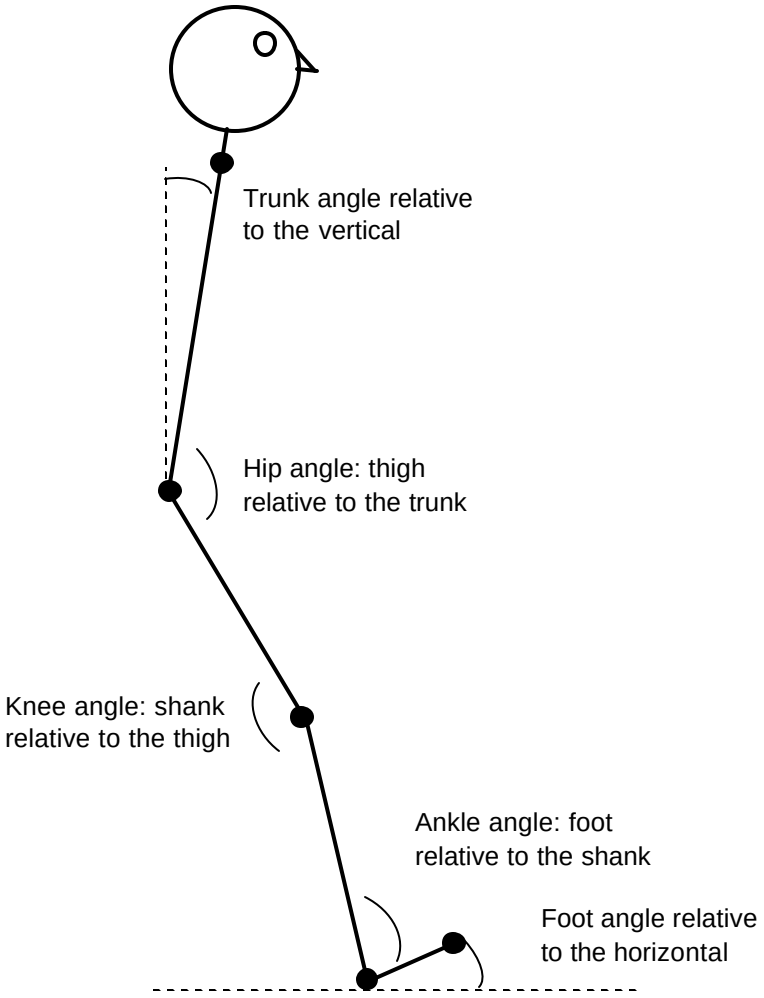

Figure 1: Schematic drawing of kinematic marker locations and calculation of joint and segment angles.

Statistical Analysis

Based on the relatively low number of subjects and the nature of this pilot study, no empirical statistical analyses were performed. All results are based on descriptive analysis between pre- and post-test measures.

RESULTS and DISCUSSION

Biomechanical Variables

A summary of biomechanical results for heel strike and midstance can be found in Table 1 and 2, respectively and a schematic drawing in Figure 2. In support of the hypotheses, runners exhibited a more mid-foot strike pattern (6.3^o closer to the horizontal) with little change in ankle flexion position (1.5^o) at heel strike. Specifically, 5 of the 6 runners demonstrated a more mid-foot strike pattern (range: 1.8^o – 10.3^o) while 1 runner showed no change (0.0^o) compared to pre-testing values. A more midfoot strike foot position with little change in ankle flexion angle suggests that little change in the alignment of the lower leg (shank) relative to the foot occurred while running and therefore a shorter stride length was used to achieve the more midfoot strike pattern. Also in support of the hypotheses, the runners were 5.2^o and 3.9^o more flexed at the knee and hip joints, respectively, at heel strike compared to pre-testing values. Overall, 5 of the 6 runners were more flexed with 1 runner showing slightly greater knee (2.0^o) and hip (1.5^o) extension at heel strike compared to pre-testing values.

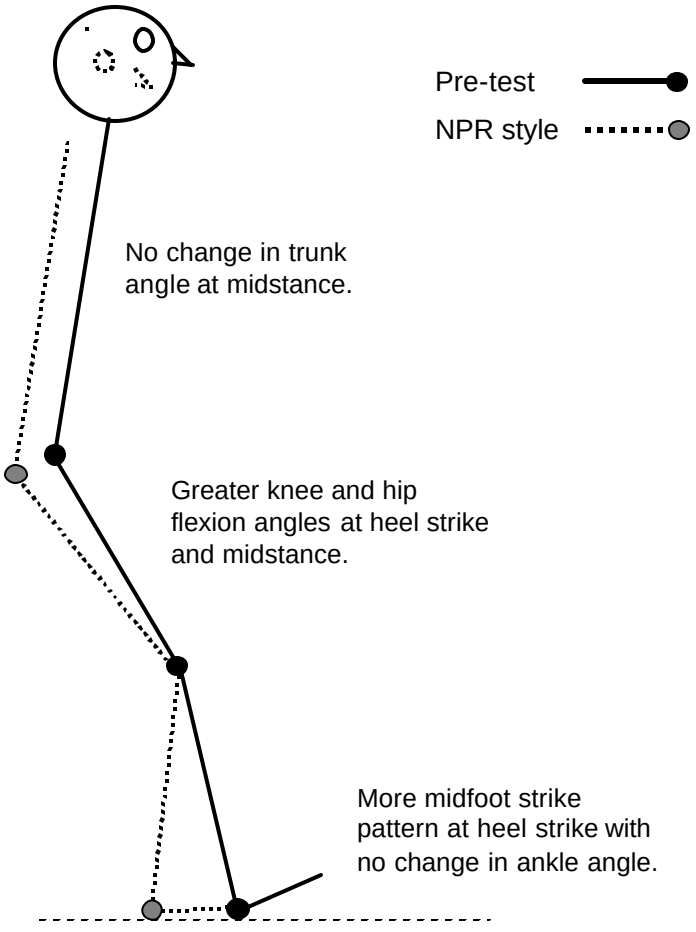

Figure 2: Schematic representation of changes in joint and segment angles while running with NPR style compared to their own pre-testing style.

During midstance, runners demonstrated a relatively small increase (1.0^o) in forward trunk lean relative to the vertical compared to pre-testing values. Three subjects exhibited between a 1.3^o and 5.5^o increase in forward trunk lean while 2 subjects showed a 1.8^o and 3.5^o backward lean and 1 subject exhibited relatively no change (0.3^o). Therefore, since only 3 of the 6 subjects demonstrated the desired trunk posture, is inconclusive whether runners adopt a more forward trunk lean while utilizing the NPR technique.

In support of the hypotheses, the runners demonstrated an overall more flexed lower extremity posture with greater ankle (1.8^o) knee (2.8^o) and hip (3.2^o) joint flexion during midstance compared to pre-testing values. No consistent pattern was observed and it can be observed in Table 2 that each subject utilized a combination of various alterations in ankle, knee, and hip joint angles combined with trunk lean to achieve an overall more flexed posture compared to their own pre-testing values.

Physiological Variables

When comparing the pre- and the post-intervention test results, there was an average of 66 second increase in pace measured in minutes per mile when running at the same heart rate. Extrapolating this increase in running economy to potential performance gains, an improvement of 6 minutes in a 10km race, 14 minutes in a half marathon and over 28 minutes in the marathon could be expected.

Limitations

Specific limitations are noted with this pilot study. First, based on the relatively low number of subjects it is difficult to draw conclusions that can be generalized to the general running population. Second, due to the length of time between pre and post testing, one could explain the improvement of increased running economy as a result of additional training. However, all subjects reported neither additional training nor change in training patterns other than incorporating the new drills and new running style into their regular running program. Finally, there are several principles of body alignment and limb position that are taught within the NPR program and only a few variables were chosen for analysis. It is therefore possible that other changes in running biomechanics were adopted following the training program which were not measured but are nonetheless necessary to successfully become an NPR runner.

CONCLUSIONS

Based on the results of the pilot study, it can be concluded that following the 5 week training program to learn the NPR running technique, runners demonstrated a mid-foot strike pattern and were more flexed at the ankle, knee, and hip joints while running. It is inconclusive whether runners adopt a more forward trunk lean while utilizing the NPR technique. In addition, the runners exhibited an improvement in running economy following the 5 week training program.

Future Directions

Further investigation with larger subject groups is necessary to better determine how the NPR running technique alters running biomechanics and running economy. Additionally, studies are necessary which include oxygen consumption and time trial data collections to better determine possible improvements in running performance as a result of improved running mechanics and posture. Further investigation is also needed to determine at what speeds or what endurance events will the NPR style improve performance most. Since the Aerobic Economy Running test represents a speed that is similar to marathon race pace, it can be speculated that this style of running may benefit marathoners or ultra endurance athletes most. Finally, it has been well documented that 50% of all runners will sustain a musculoskeletal injury each year. Therefore, longitudinal prospective studies are needed to determine if the NPR running technique results in a reduction in running-related injuries secondary to the alterations in running biomechanics and improvements in running economy as demonstrated in this pilot study.

Table 1: Individual and group values for heel strike.

		Pre-Test Measures				Post-Test Measures				Difference (Pre – Post)			
Subject No.		**Foot**	**Ankle**	**Knee**	**Hip**	**Foot**	**Ankle**	**Knee**	**Hip**	**Foot**	**Ankle**	**Knee**	**Hip**
1	**Avg**	**11.5**	**70.3**	**9.5**	**15.5**	**18.8**	**70.0**	**20.5**	**21.0**	**-7.3**	**0.3**	**-11.0**	**-5.5**
	SD	2.1	0.4	3.5	0.7	1.8	1.4	2.1	4.2				
2	**Avg**	**15.0**	**63.0**	**5.3**	**16.8**	**15.0**	**62.3**	**13.5**	**28.5**	**0.0**	**0.8**	**-8.3**	**-11.8**
	SD	4.2	2.8	0.4	2.5	4.9	4.6	3.5	2.1				
3	**Avg**	**12.5**	**63.0**	**11.8**	**31.3**	**21.5**	**62.8**	**17.0**	**32.3**	**-9.0**	**0.3**	**-5.3**	**-1.0**
	SD	3.5	2.8	0.4	1.1	3.5	5.3	4.2	0.4				
4	**Avg**	**20.0**	**66.0**	**22.5**	**24.3**	**21.8**	**67.8**	**20.5**	**22.8**	**-1.8**	**-1.8**	**2.0**	**1.5**
	SD	5.7	8.5	2.1	0.4	0.4	1.8	1.4	1.1				
5	**Avg**	**8.3**	**68.3**	**11.0**	**24.0**	**18.5**	**67.8**	**15.3**	**28.0**	**-10.3**	**0.5**	**-4.3**	**-4.0**
	SD	3.2	0.4	3.5	2.1	0.7	5.3	3.9	2.1				
6	**Avg**	**5.8**	**77.3**	**18.3**	**25.3**	**15.5**	**68.0**	**22.5**	**28.0**	**-9.8**	**9.3**	**-4.3**	**-2.8**
	SD	1.1	3.2	1.1	1.1	0.7	4.2	1.4	0.7				
Group	**Avg**	**12.2**	**68.0**	**13.0**	**22.8**	**18.5**	**66.4**	**18.2**	**26.8**	**-6.3**	**1.5**	**-5.2**	**-3.9**
	SD	5.0	5.4	6.3	5.8	2.9	3.2	3.5	4.1	4.4	3.9	4.4	4.5

Table 2: Individual and group values for midstance.

		Pre-Test Measures				Post-Test Measures				Difference (Pre – Post)			
Subject No.		**Ankle**	**Knee**	**Hip**	**Trunk**	**Ankle**	**Knee**	**Hip**	**Trunk**	**Ankle**	**Knee**	**Hip**	**Trunk**
1	**Avg**	**84.5**	**41.8**	**17.0**	**1.8**	**85.8**	**50.0**	**24.8**	**3.0**	**-1.3**	**-8.3**	**-7.8**	**-1.3**
	SD	0.7	3.2	2.1	0.4	3.9	1.4	5.3	2.8				
2	**Avg**	**84.5**	**42.3**	**26.5**	**8.3**	**89.8**	**47.8**	**36.5**	**13.8**	**-5.3**	**-5.5**	**-10.0**	**-5.5**
	SD	2.1	0.4	2.1	1.8	5.3	6.7	3.5	0.4				
3	**Avg**	**79.5**	**52.3**	**45.8**	**15.8**	**84.5**	**52.0**	**37.0**	**12.3**	**-5.0**	**0.3**	**8.8**	**3.5**
	SD	2.1	5.3	2.5	1.1	0.7	4.2	8.5	5.3				
4	**Avg**	**83.0**	**46.5**	**29.0**	**8.5**	**86.0**	**47.3**	**25.5**	**6.8**	**-3.0**	**-0.8**	**3.5**	**1.8**
	SD	5.7	3.5	1.4	0.7	2.8	0.4	2.8	0.4				
5	**Avg**	**83.3**	**41.8**	**31.5**	**11.3**	**85.0**	**48.0**	**34.0**	**11.0**	**-1.8**	**-6.3**	**-2.5**	**0.3**
	SD	8.1	1.8	6.4	0.4	2.8	1.4	5.7	1.4				
6	**Avg**	**91.3**	**51.3**	**22.8**	**4.5**	**86.0**	**47.3**	**34.0**	**9.0**	**5.3**	**4.0**	**-11.3**	**-4.5**
	SD	5.3	0.4	3.9	0.7	2.8	1.1	1.4	1.4				
Group	**Avg**	**84.3**	**46.0**	**28.8**	**8.3**	**86.2**	**48.7**	**32.0**	**9.3**	**-1.8**	**-2.8**	**-3.2**	**-1.0**
	SD	3.9	4.8	9.8	4.9	1.9	1.9	5.4	3.9	3.8	4.7	8.0	3.5