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The Effect of a Barefoot Training Program on Running Economy and Performance

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Research Articles

The Effect of a Barefoot Training Program on Running Economy and Performance

—Neil Baroody (Editor: Jennifer Lee)

Barefoot running has developed into a recent training technique for elite and sub-elite endurance runners. However, many individuals who experiment with barefoot running often succumb to injuries either by failing to gradually increase their training intensity or address their physical limitations. In spite of the many anecdotal statements that have been made suggesting the benefits of barefoot running, there have been no previous studies evaluating a systematic training program designed to safely teach this skill and then test the outcome of this training on a runner's economy and race performance.

Neil Baroody putting barefoot running to the test at UNH's Mooradian Field (*Perry Smith, UNH Photo Services*).

During the summer and fall of 2012 I participated in a two-phase research project headed by Dr. Timothy Quinn, associate professor and option coordinator for exercise science, Department of Kinesiology, which took place on the UNH campus. My work was principally in phase two where we put competitive shoe (shod) runners through a systematic training program in barefoot running to see if their running economy and race performance would improve. The hypothesis was that a ten-week structured training program to teach shod runners to run barefoot would yield an improved running economy and a faster race performance with minimal injury or soreness.

As a senior with a major in exercise science and a minor in nutrition, this was an opportunity not only to gain a more in-depth understanding of the biomechanics of barefoot running but also to work closely with a faculty member and learn what is involved in the process of research. My main role was to guide shod runners through the training program; however, I also was involved in all laboratory testing and learned to use a variety of exercise physiology research equipment. I helped recruit subjects by attending area road races and meetings of running clubs, contacting coaches and athletes, distributing flyers, and generally advertising the project.

Training Shod Runners to Run Barefoot

We proposed to recruit twenty to thirty competitive male and female runners, half being already trained barefoot runners and the other half being shod runners. These runners were required to be between eighteen and forty-five years of age, log approximately thirty miles per week, and have run a personal best of twenty-two minutes or faster in a five-kilometer (5K) run. For phase one, runners in the two groups were matched on fitness level, gender, and performance. Running economy and 5K performance of the matched runners would be measured and compared.

In phase two, volunteers among the shod runners would then be trained over ten weeks to run barefoot, and we would re-measure their running economy and performance, this time while running barefoot. Running economy is a measure of how efficiently a runner uses oxygen and is measured as the submaximal volume of oxygen (VO2) required to run at a given speed. All training took place at Mooradian Field, an artificial turf field; the Paul Sweet Oval, the UNH indoor track and field facility; and the treadmills in the UNH Employee Fitness Center.

The author (right) and his research mentor, Dr. Tim Quinn (middle), oversee the training of a research subject at UNH's Mooradian Field (*Perry Smith, UNH Photo Services).*

Before participating in the project, all the runners completed an informed consent form and had body mass and body composition measured by a skilled technician to determine percent body fat. The runners then completed a treadmill test of their ability to utilize oxygen at maximal aerobic effort (VO2max). These tests were repeated when the runners had finished the requirements of the project.

Each runner's beginning and ending running economy was determined while running on a flat, uphill (+5% grade), and downhill (-5% grade) treadmill surface as well as in a 5K time trial. Oxygen uptake (VO2) was measured using a Cosmed K4b2 portable telemetric gas analysis system that was calibrated prior to each test.

The runners taking part in the barefoot training were required to maintain their normal exercise and training routines while learning how to run barefoot. We expected that through improved foot and lower limb mechanics, force distribution, and utilization of the arch and Achilles' heel, the runners would not only learn how to correctly run barefoot but, through improved running biomechanics, would have an enhanced running economy and a faster 5K.

During the ten-week barefoot training regimen, I acted as coach and closely monitored the runners' training volume and schedules, soft-tissue routines, dynamic warm-ups, and running mechanics. Avoiding injuries was a major concern in the design and carrying out of the progressive training regimen.

Each week, the runners spent progressively more time barefoot running than barefoot walking. For example, week one required nine minutes of barefoot walking, followed by one minute of barefoot running. Week four required six minutes of barefoot walking, followed by four minutes of barefoot running. Week seven required two minutes of barefoot walking, followed by eight minutes of barefoot running. This cycle was then repeated two more times, resulting in a thirty-minute training session. The one exception was week ten, which required the subjects to complete two, twenty-minute barefoot sessions, with only a short recovery. (Table 1)

	Monday	Wednesday	Friday	Saturday
Week 1	Walk 9 mins/Run 1 min x 3 (30 mins Total)	Walk 9 mins/Run 1 min x 3 (30 mins Total)	Walk 9 mins/Run 1 min x 3 (30 mins Total)	Walk 9 mins/Run 1 min x 3 (30 mins Total)
Week 2	Walk 8 mins/Run 2 mins x 3 (30 mins Total)	Walk 8 mins/Run 2 mins x 3 (30 mins Total)	Walk 8 mins/Run 2 mins x 3 (30 mins Total)	Walk 8 mins/Run 2 mins x 3 (30 mins Total)
Week 3	Walk 7 mins/Run 3 mins x 3 (30 mins Total)	Walk 7 mins/Run 3 mins x 3 (30 mins Total)	Walk 7 mins/Run 3 mins x 3 (30 mins Total)	Walk 7 mins/Run 3 mins x 3 (30 mins Total)
Week 4	Walk 6 mins/Run 4 mins x 3 (30 mins Total)	Walk 6 mins/Run 4 mins x 3 (30 mins Total)	Walk 6 mins/Run 4 mins x 3 (30 mins Total)	Walk 6 mins/Run 4 mins x 3 (30 mins Total)
Week 5	Walk 5 mins/Run 5 mins x 3 (30 mins Total)	Walk 5 mins/Run 5 mins x 3 (30 mins Total)	Walk 5 mins/Run 5 mins x 3 (30 mins Total)	Walk 5 mins/Run 5 mins x 3 (30 mins Total)
Week 6**	Walk 3 mins/Run 7 mins x 3 (30 mins Total)	Walk 3 mins/Run 7 mins x 3 (30 mins Total)	Walk 3 mins/Run 7 mins x 3 (30 mins Total)	Walk 3 mins/Run 7 mins x 3 (30 mins Total)
Week 7	Walk 2 mins/Run 8 mins x 3 (30 mins Total)	Walk 2 mins/Run 8 mins x 3 (30 mins Total)	Walk 2 mins/Run 8 mins x 3 (30 mins Total)	Walk 2 mins/Run 8 mins x 3 (30 mins Total)
Week 8	Walk 1 mins/Run 9 mins x 3 (30 mins Total)	Walk 1 mins/Run 9 mins x 3 (30 mins Total)	Walk 1 mins/Run 9 mins x 3 (30 mins Total)	Walk 1 mins/Run 9 mins x 3 (30 mins Total)
Week 9**	Run 10 mins/Short Recovery x 3 (30 mins Total)	Run 10 mins/Short Recovery x 3 (30 mins Total)	Run 12 mins/Short Recovery x 3 (36 mins Total)	Run 12 mins/Short Recovery x 3 (36 mins Total)
Week 10**	Run 15 mins/Short Recovery x 2 (30 mins Total)	Run 15 mins/Short Recovery x 2 (30 mins Total)	Run 20 mins/Short Recovery x 2 (40 mins Total)	Run 20 mins/Short Recovery x 2 (40 mins Total)

Table 1: Progressive, 10-week barefoot running training program.

Results, Difficulties and Benefits

By mid-December, over thirty competitive runners had participated in the research project, while only eighteen completed all of the phase one requirements. Four of the eighteen athletes were females, with an average age of twenty-three years, while the remaining fourteen runners were males, with an average age of thirty-five years. Data for phase one is still being compiled and analyzed.

Seven of the male athletes took part in the barefoot training study. By publication date, three had completed the ten-week training program and the follow-up testing. Their results are analyzed below.

Figure 1 shows the average VO2max of the three subjects. Despite ten weeks of barefoot training, there was not a significant change in the runners' maximal oxygen consumption. VO2max is measured in milliliters of oxygen per kilogram of body weight per minute (mL/kg/min), which reflects one's ability to process and utilize oxygen while sustaining intense aerobic exercise.

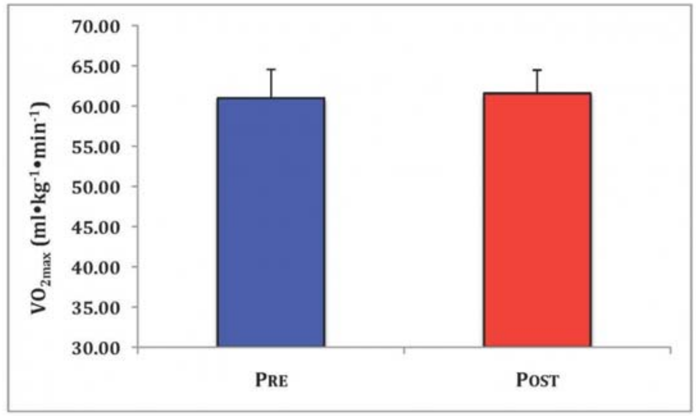

Figure 1: VO2max measured pre- and post-barefoot training.

Figure 2 shows a distinct decrease in VO2 at the three pre-determined treadmill grades and speeds following ten weeks of barefoot training. In other words, these athletes required less oxygen to fuel their muscles at the prescribed treadmill grades and speeds. Since the runners improved their ability to convert metabolic energy to mechanical energy, it is reasonable to conclude that these individuals had improved their running economy.

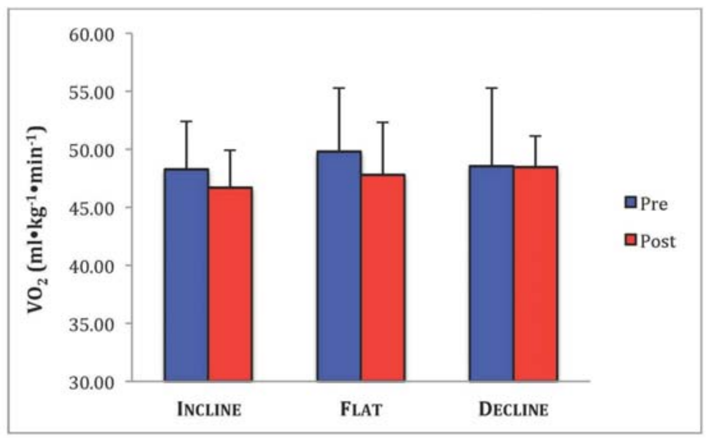

Figure 2: VO2 measured pre- and post-barefoot training while running on an uphill, flat, and downhill treadmill grade.

Figure 3 shows that the subjects, on average, had equal times pre- and post-training at the one-mile mark, but faster two-mile and three-mile times (mile splits) after their barefoot training and while running barefoot. A similar trend can be observed in Figure 4, as the runners completed the 5k time trial (running barefoot) nearly thirty seconds faster than before training, while running shod. These faster times may have been due to the noticeable improvements in running economy (as seen in Figure 2) and to improved foot and lower limb mechanics, force distribution, and utilization of the arch and Achilles' heel in barefoot running.

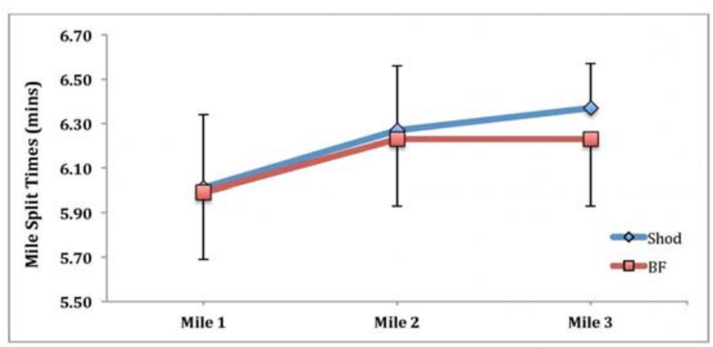

Figure 3: Mile splits in minutes pre-training (shod) and post-training (barefoot).

According to the above figures, it is reasonable to conclude that our hypothesis was supported within this small subject population. The small amount of variability in the VO2max data, in comparison to the noticeable changes in the VO2 data, suggests that these improvements have more to do with improved biomechanics due to the barefoot training as opposed to increases in aerobic capacity. However, in order to improve the credibility of these findings, it is imperative to recruit more runners who are willing to complete the ten-week barefoot training program.

Although we tested a sufficient quantity of subjects, we were not immune to unexpected and unfortunate setbacks. Two of the most consistent were untimely breakdowns of the prescribed physiological equipment and conflicts interfering with the scheduling of subjects for barefoot training and/or testing.

The Cosmed K4b2 analyzer, the system we utilized to measure oxygen uptake, malfunctioned from time to time, which required retesting some subjects and re-familiarizing ourselves with the testing system. The runners' minor injuries and personal setbacks along with inclement weather made it sometimes difficult to consistently monitor training and schedule follow-up testing in a timely manner. However, careful alterations in their training program and increased availability on our behalf allowed them to successfully complete the training and improve their chances of performing optimally.

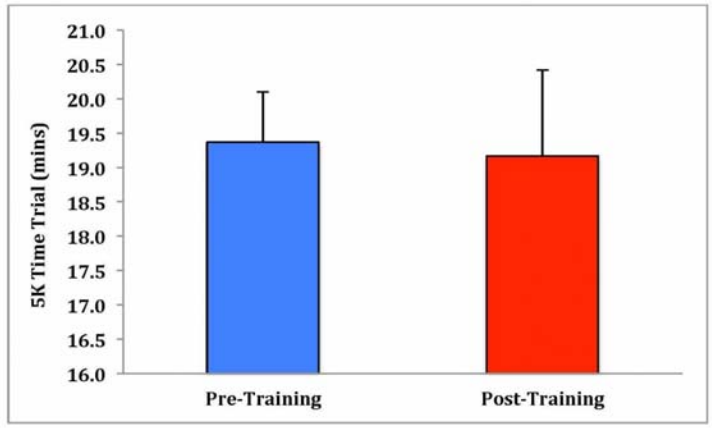

Figure 4: Five-kilometer time trial pre-training (shod) and post-training (barefoot).

Due to the amount of time and effort required to complete the requirements of the study, it should not have been unreasonable to expect occasional equipment malfunctions and time conflicts. In other words, the equipment was consistently stressed due to the multitude of physiological tests; and the twelve-week commitment of the shod runners, who decided to participate in the barefoot training program, was long but necessary to generate sufficient data.

During this project, I was also challenged academically and personally. Since the athletes were required to undergo VO2max, running economy, and 5K tests, it was essential that I understood how to operate a complex, portable oxygen uptake system and a treadmill with embedded force plates along with their associated software. From a personal standpoint, I worked to improve my punctuality by responding promptly to emails and phone calls, contacting subjects consistently, checking in regularly with my research mentor, and traveling to club meetings and road races when necessary.

This project served as my first real coaching experience. As a result, I quickly understood the importance of regular communication and the unique physiological and psychological demands of each athlete. Since each athlete may respond differently to certain training methods and coaching cues, it is imperative to understand not only your athlete's physical abilities but also his or her mental capabilities. Due to the experience gained from participating in this research project and as I accumulate more coaching experience, it will become easier for me to prescribe appropriate training methods and cues to my own athletes.

Following completion of this lengthy research process, I would like to thank the Hamel Center for Undergraduate Research, for their generous donation and all the time and support they provided. I would also like to thank my research mentor, Dr. Timothy Quinn, and my research partner, Corie Mae Callaluca, for all their assistance and encouragement as we spent many days and hours in the lab, working towards a common goal. A big thank you also goes out to the UNH Media Relations for all their time, effort, and interest and for sharing this research with the general public. I want to thank my parents, family, friends, professors, and classmates for your interest in this project. It was a pleasure to share my experiences with all of you! Last, but certainly not least, I want to send out my appreciation to all the individuals who decided to participate in this research study. It was a pleasure getting to know and learn from all of you!

Author and Mentor Bios

Senior, **Neil Baroody** of Londonderry, New Hampshire, is majoring in kinesiology: exercise science, minoring in nutrition, and is also a member of the University Honors Program. He was pleased to join his advisor, Dr. Timothy Quinn, in this research project, specifically for the coaching experience it provided. His participation was supported by a Student Undergraduate Research Fellowship (SURF) award from the Hamel Center for Undergraduate Research. The summer project, during which he coached athletes often ten years older than he, was challenging but incredibly rewarding. “This project,” he said, “forced me to step outside of my comfort zone and exposed me to numerous variables involved in becoming a better leader and person.” Neil's goal is to become an accomplished Olympic sprint coach.

Dr**. Timothy Quinn**, an associate professor in the Department of Kinesiology at the University of New Hampshire, has been teaching at UNH for twenty-four years. He said he likes to think that he specializes in "both teaching and research, [but] my favorite teaching specialization is electrocardiography and my broad area of research is cardiovascular function." As a runner himself, he has always been interested in how to make runners run faster and was intrigued by the rise of the barefoot running community in the past few years. Dr. Quinn enjoys mentoring undergraduate students and said, "For me the most satisfactory aspect of the entire research process with undergraduate students is to see the 'light go on' in students' eyes! They see something they have been taught in the classroom come to life for them in the laboratory, and they begin to see the application behind the research process." Students should learn to write for a broad audience like *Inquiry*'s, Dr. Quinn feels, "because research is not just for the scientific community but for the public."

Contact the author >>

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