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Can Simple Postural Instructions Modify Running Forms in Recreational Runners

Casey Gray
University of Nevada, Las Vegas

Matthew Poggemiller
University of Nevada, Las Vegas

Ian Tracy
University of Nevada, Las Vegas

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RUNNING FORMS IN RECREATIONAL RUNNERS?

By

Casey Gray

Matthew Poggemiller

Ian Tracy

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Casey Gray, Matt Poggemiller, Ian Tracy

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Jing Nong Liang, Ph.D.
Research Project Coordinator

Szu-Ping Lee, Ph.D.
Research Project Advisor

Kathryn Hausbeck Korgan, Ph.D.
Graduate College Dean

Merrill Landers, Ph.D.
Chair, Department of Physical Therapy

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ABSTRACT

Purpose/Hypothesis: Recent research suggests that alteration of trunk angle and foot strike pattern during running may result in beneficial changes that prevent running related injuries due to reduction in vertical ground reaction forces (vGRF). For example, running form emphasizing a forward trunk lean and a midfoot or forefoot strike pattern has been shown to be effective in reducing knee stress and the risks of other impact-related running injuries. In clinical practice however, it is currently unknown if simple postural cues given to runners can elicit motor learning that leads to modification of running form. The purpose of this study was to analyze the biomechanical changes in the running form of recreational runners after being instructed to run with a forward trunk lean and a forefoot strike pattern over a 4-week training period.

Methods: Eighteen runners, 11 females and 7 males, mean age 28.5±6.10 years, mean body mass index= 23.18 kg/m^2, that run at least five miles per week and are injury free at the time of the study participated. During a 4-week training period, the runners received the following simple postural instructions: 1) lean your trunk forward and 2) land on the front part of your foot. The runners were asked to focus on these postural cues whenever they ran on their own during the 5-week study period. Participants were assessed at the following time points: prior to training (PRE), immediately after receiving the instructions (iPST), at 2 weeks (2WK) and 4 weeks (4WK), and 7-10 days after the conclusion of training (RET). Assessment consisted of an initial running trial on a treadmill during which trunk angle and peak vertical ground reaction force (vGRF) in stance phase were assessed using a 3D motion capture system and a force plate-instrumented treadmill. The runners were assessed at their self-selected running speed and a predetermined speed of

2.5 m/s during which three 20-second trials were collected for each speed. One-way re-

peated measures ANOVA tests were used to compare the changes in trunk angle and

peak vGRF over time.

Results: There was a significant increase in forward trunk angle during running immedi-

ately after receiving the instructions for both running speeds (PRE vs. iPST, self-selected

speed: 6.69º vs. 9.76º, p=0.001; 2.5m/s: 6.78º vs. 9.14º, p=0.005). When compared to

PRE, there was a significant increase in trunk flexion angle at 4WK (PRE vs. 4WK, self-

selected running speed: 6.69º vs. 9.94º, p=0.031; 2.5 m/s: 6.78º vs. 10.05º, p=0.002).

When compared to PRE, there was a significant increase in trunk flexion angle at RET at

2.5 m/s speed (PRE vs. RET: 6.78º vs. 9.99º, p=0.044), however there was no significant

increase in trunk flexion angle at RET for the self-selected speed (PRE vs. RET: 6.69º vs.

9.45º, p=0.111). There was no significant change in vGRF over the course of the training

for the self-selected and 2.5 m/s speeds (p=0.644 and 0.187, respectively).

Conclusions: Based on our findings, we conclude that simple postural instructions and

training over 4 weeks can induce changes in trunk angle during running in recreational

runners. However, vGRF may not significantly change after alteration of trunk posture.

Clinical Relevance: This study demonstrated that simple postural instructions can in-

duce short- and mid-term changes in running form in recreational runners.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Running for sport, general fitness, weight loss, and conditioning for other sporting activities has a long history as a method of exercise that has waxed and waned, showing increased popularity in recent years. According to Running USA, there has been more than a 140% increase in U.S. marathon finishers and a 40% increase in the past decade alone with 2014 holding the record high of 550,600 people finishing marathons.[1] More than 36 million people in the United States run for exercise or sport as of 2013.[2] With an overall increase in runners, the number of injuries is also on the rise. One recent study reported that half of all runners sustain at least one running-related overuse injury every year.[3] The knee is the most commonly injured joint in marathon runners with yearly injury rates reported to be as high as 90%.[4]

Traditional running style can be traced to the running boom of the 1970's. Although this was a time when the popularity of running rose, it was also one that saw a rise in the rate of running-related injuries.[5, 6] Coaches and professionals alike postulated that the injury rate could be mitigated by new technology rather than the adjustment of variables such as training intensity, mileage, or running form. This led to the development of shoes with well-cushioned heels that allow a runner to land directly on the heel, roll forward across the entire foot and push off from the toes. However, this invention is thought to have spurred even more runners to utilize a rearfoot strike pattern: it is now estimated that 89% of all shod runners use a rearfoot strike pattern. Unfortunately, injury rates have not changed significantly after this adjustment in running shoe style.[7] Shoe types ranging from supportive and well cushioned to minimalistic or even barefoot have risen and fallen in popularity ever since the 1970's and runners and coaches alike are still attempting to find footwear that can guarantee the lowest risk for injury.[5, 8]

1

Research now suggests that the adjustment of biomechanical variables such as footstrike pattern and body or trunk posture are perhaps more important than shoe type when attempting to lower injury risk in the lower extremity. Kinematic assessment of the individual's running mechanics is a common method of recognizing and managing running related injuries. For example, the most common running related injury is patellofemoral pain syndrome, the cause of which is thought to be elevated patellofemoral joint (PFJ) stress.[9] Changing running form has shown to decrease patellofemoral joint stress. Increasing step rate, changing foot strike pattern, and leaning the body forward with the ankles, hips, and shoulders aligned are examples of how runners have changed their running form in an effort to decrease impact stress.[10-13] Since running results in thousands of foot strikes in a given bout, reducing the amount of impact absorbed by the body during each foot strike may decrease cumulative stress and lower injury risk.[6, 9, 14]

A method of running shown to attenuate impact is a style that emphasizes midfoot or forefoot strike.[3, 15, 16] Cheung and Davis found in their case study that peak vGRF was decreased significantly when runners changed from a rearfoot strike pattern to a forefoot strike pattern.[17] This conflicts with results from another study which found that rearfoot striking resulted in similar peak vGRF when compared against runners who performed midfoot or forefoot striking.[15] Thus, it is unknown whether or not peak vGRF is significantly different depending on foot strike pattern.

However, studies do agree that runners who run with a traditional heel strike pattern exhibit a higher loading rate of vertical ground reaction force, which results in a vertical impact transient force at heel strike before reaching peak vGRF. In comparison, runners who land on the middle or front part of their foot tend to smoothly transition to peak vGRF without a vertical impact transient.[15] This increased loading rate in the early stance phase in rearfoot striking has

been associated with increased injury risk.[8]

Other studies have shown promising benefits from trunk flexion alone, regardless of whether a runner is rearfoot or forefoot striking. Runners who have a forward flexed trunk posture (regardless of shoe type or foot strike pattern) are able to produce similar impact reduction results as measured by vGRF loading rate and maximum braking force when compared to runners who are forefoot strikers.[3, 16] Teng and Powers showed that increasing forward trunk flexion alone by even as little as 7.2° can have similar effects on the biomechanics and energetics of the knee as adopting forefoot strike without increasing the demand on the ankle plantarflexors seen in forefoot striking runners.[18] This study reported that knee extensor energy absorption was decreased by up to 23.3% while hip extensor activity was increased by up to 140% when a runner has a forward flexed trunk posture.[10] Thus, load and strain is shifted from the knee extensors to the larger and more proximal hip extensor muscles by increasing trunk flexion angle.

In summary, these studies have suggested that a running form emphasizing a forward trunk lean and/or a midfoot to forefoot striking pattern will decrease lower extremity injury and pain risk. Most, if not all, of these studies agree that decreased risk of injury from changing running posture is likely due to the re-distribution of mechanical energy to the foot, knee, and hip, as well as decreased vGRF loading rate, maximum braking force, and decrease or absence of an impact transient during foot strike.[9, 10, 12]

However, the amount of education, instruction, and feedback by which runners can best learn and retain a form with a forward trunk lean and anterior foot strike is currently unknown considering the durability of locomotive motor patterns. Running as a motor activity develops in childhood as a natural progression of motor development. Running is typically mastered in children by age 5. The motor patterns necessary for each phase of movement are developed with

3

practice over time.[19] Repetitive locomotor activities such as walking and running develop strong attractor states as neural patterns due to the high number of gait cycle repetitions. As a person progresses toward adulthood, these attractor states become stable and durable. Consider a runner who decides to go on a 3-mile training run: this person will perform close to 5000 repetitions of the movement. If the movement pattern is not biomechanically efficient, injuries may result from the repetitive movement. Furthermore, when a runner's training volume increases such as when preparing for a race, the chance of injury from small deficiencies in technique becomes greater. The stable neural patterns developed through this learning process can be difficult to change and may contribute to the increased injury risk when training volume increases.[6, 20, 21] Common running-related injuries such as PFJ and iliotibial band stress syndrome are strongly linked to overuse and over-training.[4] Therefore, given the evidence of potential benefits of running re-education, determining the best method for gait modification is imperative for clinicians to address.

The current literature regarding motor learning in running is limited. Attentional focus, feedback, simple instruction, and practice have all been shown to increase motor performance, learning, and retention in discrete sporting tasks.[8, 22, 23] However, activities such as running and swimming are continuous tasks without finite goals and thus immediate feedback and knowledge of results are unattainable. Thus, one cannot assume that a runner can be re-trained to use a different posture using the same means used to re-train athletes who practice discrete tasks. It is currently unclear what factors can influence learning retention of running movements.

The purpose of this study was to analyze the effects of simple postural instructions on producing trunk forward lean and reduction of vertical ground reaction force in runners during a 4-week training period. Our hypotheses are:

- Hypothesis 1: After being instructed to "lean your trunk forward and land on the front part of your foot", the participants will adopt a more efficient running form as demonstrated by an increased trunk flexion angle and decreased peak ground reaction force when compared to their running trials before cues were received.

- Hypothesis 2: Participants will successfully retain the modified running form as demonstrated by maintaining that form one week after their last instructional session.

This study will allow us to gain knowledge regarding the use of simple instruction and training to elicit changes in running movement patterns. Furthermore, information gained from this research will help progress the field of motor learning in rehabilitation and prevention of running related injuries.

METHODS

Subjects

Eighteen recreational runners were recruited based on the following criteria: 1) participants must be between 18 and 45 years of age, 2) injury-free at the time of the study, and 3) must run at least 5 miles or 3 times per week before the study begins. Average age of participants calculated to be 28.5 ± 6.10 years with 11 females and 7 males, average BMI = 23.18 kg/m^2. Exclusion criteria included: 1) individuals who have taken any ChiRunning workshops or tried to learn the ChiRunning style, 2) had orthopedic surgeries that permanently alter musculoskeletal structure (e.g. joint replacement, ACL reconstruction, discectomy), 3) had any major injuries or conditions that prevent running within the previous 6 weeks, and with any current injuries or conditions (such as conditions that affect balance) that may prevent running safely on a treadmill.

Instrumentation

Foot strike pattern was recorded by dividing the foot into 3 imaginary and equal parts (forefoot, midfoot, and rearfoot), and analysis via camera footage was performed to determine which of the 3 imaginary parts strikes the ground first while the athlete was running. Using a Vicon Bonita motion capture system and Nexus software collecting at 200 Hz, trunk angle was defined as the orientation of the trunk in relation to the lab coordinate system. The kinematics of the trunk was determined by using a reflective marker cluster plate, which included four markers placed on the back between T1 and T5. See below figures as a visual aide.

Figures 1 & 2: Coronal and sagittal plane views of marker placement
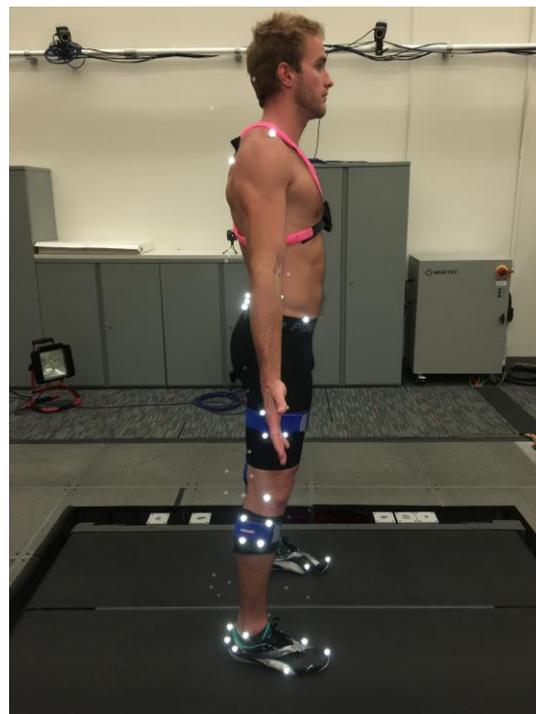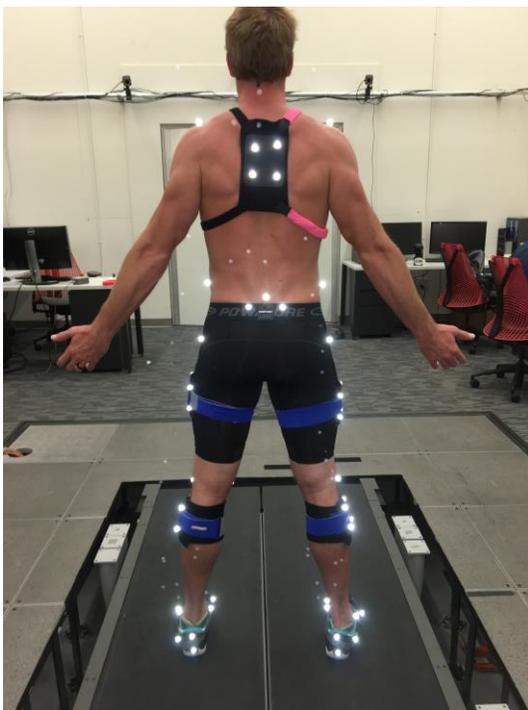
A Bertec fully instrumented treadmill was utilized for running and the collection of vGRF data. The vGRF data was sampled at 2000 Hz.

Study Design

Prior to participation, an investigator verbally explained the purpose and the procedure of the study to a potential participant. If the potential participant was interested in participating in the study, informed consent, approved by the University of Nevada, Las Vegas Institutional Review Board for Biomedical Research, was obtained. An interview by one of the investigators and a written questionnaire was given to help determine the eligibility of the participant. If the participant fit the inclusion criteria and did not exhibit any of the items in the exclusion criteria, the participant was enrolled into the study.

Participants were assessed prior to the training (PRE), immediately after receiving the instructions (iPST) on day 1, at 2 (2WK) and 4 (4WK) weeks, and 1 week (RET) after the conclusion of training (Figure 3). At the 2WK and 4WK sessions, instructions were again provided as reinforcement.

Running Biomechanics Assessment

Participants completed a pre-instruction running session, Session 1A (PRE). During this time, participants ran on the treadmill with their preferred running form. The runners were given a 5-minute warm up period at a self-selected speed and then asked to run for 2 minutes at a self-selected speed which he or she would use during a training run and at the pre-determined speed of 2.5 m/s. The participants were given one minute to acclimate to each speed before data collection occurred in three trials, with each trial lasting 20 seconds in duration. Once the participants completed the initial running protocol, the runners were given a 10-minute rest to prepare for the initial instruction session. During this time, the participants were given postural instructions and verbally repeated these instructions back to an investigator (Table 1).

During Session 1B (iPST), participants applied the postural instructions, allowing the

investigators to measure the acute effect of the cue. The runners participated in the same running protocol as Session 1A, with the exception of a shortened 2-minute warm-up at a self-selected speed and then running 2 minutes each at the predetermined speed of 2.5 m/s and again at a self-selected speed that was not necessarily the same speed as session 1A. Participants were asked to practice the cues and record their weekly running mileage and time on a pamphlet that also included a reminder of the postural instructions. Sessions 2 (2WK) and 3 (4WK) followed the same running protocol as Session 1B. Session 4 (RET) consisted of the same running protocol without the running form modification instructions being reinforced, allowing investigation of retention across time.

In order to measure the effect of only the simple postural cues, no feedback about a participant's performance was given, focusing instead on the reinforcement of the simple instructions. At the beginning of each session, a questionnaire was used to evaluate the runner's comments or complaints about the training. Visual foot strike assessment (analyzing a runner's foot strike on a video, usually slowed down) has been used in past studies. However it can be subjective since definition of rearfoot, midfoot, and forefoot is variable; therefore, it is not included in the results. Previous studies have used the strike index [24, 25] as the gold standard for foot strike assessment as it was found only 60% of foot strikes were determined correctly using the foot strike angle. Instead, the discrete variables of vGRF and trunk angle were measured.

Table 1: Simple Postural Cues

Instructions to Runners
"Lean your trunk forward" **"Land on the front part of your foot"**

<u>Figure 3</u>: Protocol timeline

Initial Visit	**2-week follow up**	**4-week follow up**	**5-week follow up: Retention Assessment**
Consent and eligibility screening	Reinforce instructions	Reinforce instructions	Biomechanical assessment: no reinforcement
Pre-instruction Biomechanical assessment	Biomechanical assessment	Biomechanical assessment	
Acute post-instruction Biomechanical assessment			

Reliability

Prior to data collection, the test-retest reliability of obtaining trunk kinematics during running was established. Trunk flexion angle was assessed in five runners over 2 different days. The intra-rater reliability of measuring the trunk kinematics was high (ICC$_{3,1}$=0.866, absolute agreement). The standard error of measurement based on the between subject variance and reliability was 2.74 degrees.

Data Analysis

Using the Vicon digital motion-capturing system, each reflective marker was labeled corresponding to its anatomical landmark and each running trial was edited to include 10 consecutive steps or 5 consecutive strides. These labeled files were then transferred to the Visual 3D software (C-Motion, Rockville, MD) where each trial was viewed to ensure labeling was accurate. The biomechanical outcome measures of interest are peak vGRF and trunk angle. Trunk angle was calculated as the motion of the trunk segment relative to the global vertical axis in the sagittal plane. The mean peak vGRF and trunk angle data was obtained from each of the three 20-second running trials to determine the peak vGRF and trunk angle in each stance phase (10

total), then averaged. A customized MatLab (MathWorks, Natick, MA) code was used to perform the data analysis.

Statistical Analysis

One–way repeated measures ANOVA was performed for self-selected speed and 2.5 m/s trials to analyze participant's average trunk angle and peak vGRF for each session. Mauchly's Test of Sphericity was used to determine compound symmetry. If Mauchly's Test was violated, Greenhouse-Geisser statistics were generated. When significant ANOVA main effects were detected, appropriate post-hoc analyses with Least Significant Difference adjustment were conducted. Level of significance for all analyses was set at 0.05. Data was analyzed using SPSS Statistics version 22 (International Business Machines Corp., Armonk, NY, USA).

RESULTS

Eighteen male and female recreational runners were subjects in this study. Demographic data of these runners are seen in the table below:

Table 2: Trunk angle analysis for self-selected speed trials of participants.

Males	7
Females	11
Mean Age	28.5 years
Mean prior weekly mileage	10.95 miles
Mean weekly mileage during study	9.33
BMI	23.18 kg/m^2
Pre Mean Trunk Flexion Angle, 2.5 m/s	6.77 degrees
Pre Mean Trunk Flexion Angle, Self-selected speed	6.69 degrees
Mean self selected speed (no significant difference across sessions)	2.83 m/s

Mauchly's Test of Sphericity returned a value of 0.052, not significant, and therefore the test is not violated. However even if it were considered significant, the Greenhouse-Geisser significance level was found to be p = 0.005 therefore showing significant time effect on trunk angles (p = 0.005, Greenhouse-Geisser adjusted F = 5.435). Bonferroni post-hoc comparison showed that the mean trunk angle of PRE is significantly less than iPST and 4WK (6.69° ± 6.10° vs. 9.76° ± 6.18°, p = 0.001; 6.69° ± 6.10° vs. 9.94° ± 5.24°, p = 0.001 respectively)(Table 3).

Table 3: Within-subjects test of sphericity for self-selected speed trials.

Mauchly's Test of Sphericity	p = 0.052	Sphericity not violated
Greenhouse-Geisser	p = 0.005	F = 5.435

Table 4: Average trunk angle across all participants during self-selected speed trials with corresponding p-values compared to PRE.

	Mean Trunk Angle (º) and Standard Deviation	P-value
PRE	6.686 ± 6.1	--
iPST	9.7597 ± 6.18	0.001
2WK	8.3625 ± 4.74	0.521
4WK	9.935 ± 5.24	0.001
RET	9.4697 ± 4.81	0.111

Table 5: Average trunk angle across all participants during 2.5m/s speed trials with corresponding p-values compared to PRE

	Mean Trunk Angle (º) and Standard Deviation	P-value
PRE	6.775 ± 5.78	--
iPST	9.154 ± 5.51	0.005
2WK	10.077 ± 3.87	0.014
4WK	10.05 ± 5.15	0.002
RET	9.994 ± 4.32	0.044

For average trunk angles as seen in table 4 following same procedure as above for participants running at 2.5m/s, Mauchly's test of Sphericity is not violated with a significance level of 0.245 and a significant Greenhouse-Geisser score (p = 0.001, Greenhouse-Geisser adjusted F = 6.658). Trunk angle significantly increased compared to PRE as Bonferonni post-hoc shows that PRE has significantly less forward trunk lean than all other sessions (6.78 ± 5.78 PRE vs. 9.14 ± 5.51 iPST, p = 0.005; 6.78 ± 5.78 PRE vs. 10.08 ± 3.87 2WK, p = 0.014; 6.78 ± 5.78 PRE vs. 10.05 ± 5.15 4WK, p = 0.002; 6.78 ± 5.78 PRE vs. 9.99 ± 4.32 RET, p = 0.044).

Figure 3: Trunk angle across sessions at self-selected speed and 2.5m/s
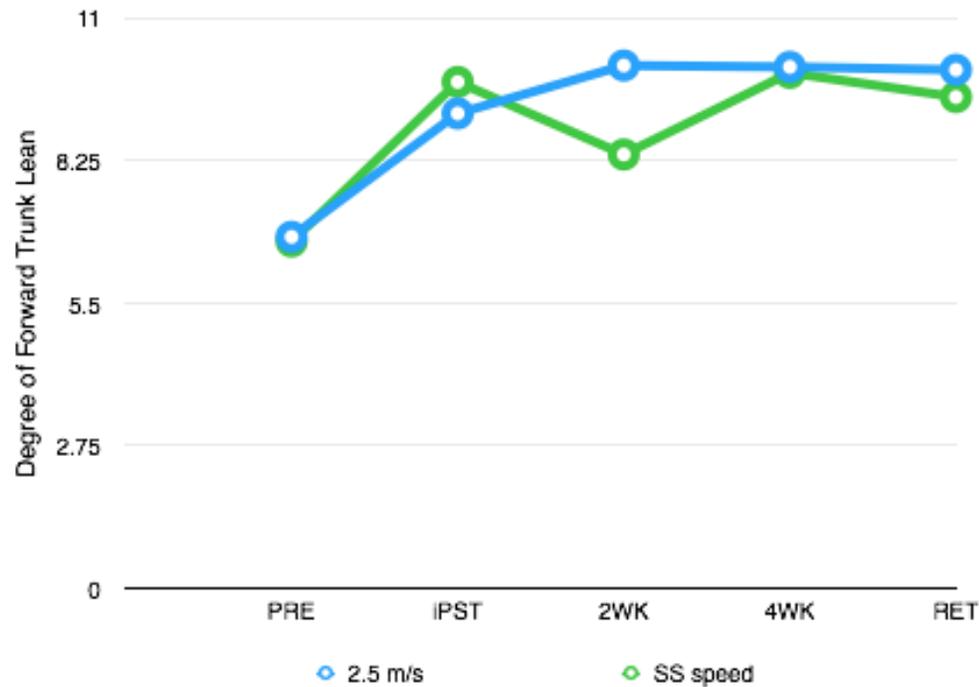
One way repeated measures ANOVA was also completed to determine mean peak vGRF change over time for participants. For the self-selected speed, Mauchly's Test of Sphericity is not violated with a p-value of 0.582, however there was no significant change in peak vGRF according to the Greenhouse-Geisser analysis ($p = 0.644$, Greenhouse-Geisser adjusted $F = 0.585$). For 2.5m/s speed, Mauchly's test of Sphericity was violated with $p = 0.007$. Furthermore, Greenhouse-Geisser again showed no significant change in vGRF over time with training ($p = 0.187$, Greenhouse-Geisser adjusted $F = 1.704$). Although no vGRF values were significant, there is a trend of increased vGRF across time, particularly between PRE and iPST as can be visualized in Figure 4.

Figure 4: vGRF at 2.5m/s and self-selected speed
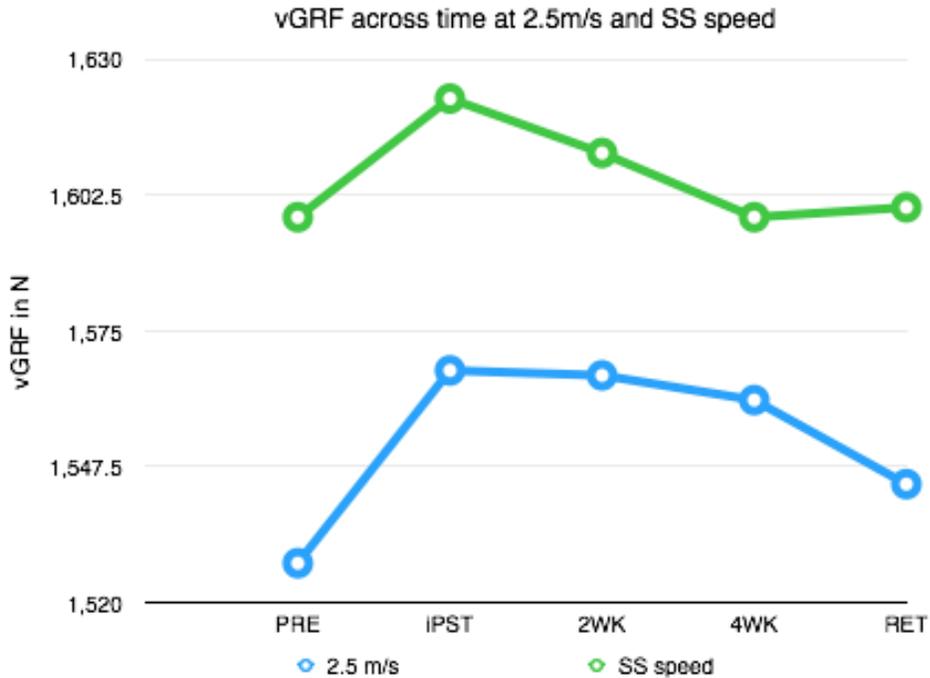
DISCUSSION

The objective of this study was to examine the effects of simple postural cues on running

form over a 5-week program. Specifically, our study looked at differences in peak vGRF and

trunk angle at two speeds: a self-selected speed and 2.5m/s. By training runners to adopt this

running form, a decrease in peak vGRF and increase in forward trunk angle was expected. Our

findings supported our first hypothesis by demonstrating that when given two simple postural

cues, recreational runners can change their running form to incorporate an increased trunk flex-

ion angle. For the self-selected and the 2.5 m/s speed, participants showed statistically significant

changes in trunk flexion angle after receiving postural instructions.

Taking a closer look at the self-selected speed and 2.5 m/s speed in regards to trunk angle over time, it was revealed that the self-selected speed only created a statistically significant change in trunk flexion angle during the first session. There was not a significant change in speed over time for the self-selected speed. However, it is worth noting the iPST speed is slightly slower than all other self-selected speeds. It is possible that immediately after receiving instruction, the participants had to slow down in order to execute the changes in posture. Therefore, speed may be a contributing factor when changing running form. For the 2.5 m/s condition, there was a statistically significant change in trunk flexion angle between the first session before instruction and all others including the retention session (RET). This indicates that the participants must be reminded to think about forward trunk lean to achieve significant results. However, a control group without additional cueing was not included in the study to test if this is a reliable statement.

Teng and Powers reported that a difference of 7.2 degrees of trunk flexion resulted in 23.3% lower energy absorption and 13.3% lower generation of knee extensors versus participants with a more upright trunk posture.[10] However when comparing mean forward trunk angles across conditions, there was only about 3 to 4 degree increase. This may be due to the fact that we did not give explicit feedback to the runners regarding their trunk flexion angle during running. Instead, runners were allowed to adjust their running posture based on their comfort, flexibility, individual interpretation of cues, and other preferences. We chose to not provide explicit feedback on trunk angle and vGRF to mirror the typical clinical scenario where real-time kinematic and vGRF feedback is not available. Furthermore, the runners often have to determine independently a reasonable degree of forward trunk lean during training. One possible confound-

ing factor was that participants had to transition from outdoor running to running on a stationary treadmill during the duration of the study.

For the 2.5m/s speed comparing the 2 trials of session 1, it is interesting to note that the peak vGRF actually significantly increased following instruction, (PRE mean peak vGRF = 1528.4 N, iPST mean peak vGRF = 1566.7 N). However there was no significant difference between PRE mean peak vGRF and 4WK or RET mean peak vGRF. A possible explanation for this particular increase from PRE to iPST is if the participant did not receive enough recovery time between running sessions then vGRF would increase due to decreased control of foot contact.

Another possible reason for the lack of significant change in the peak vGRF may be that explicit feedback on foot strike pattern and impact force was not provided. There have been many research studies using various forms of biofeedback for gait retraining in children with cerebral palsy [26] and adults post CVA.[27] However, very little research has been done regarding biofeedback for running. Another study used videotaping, which was shown to the participants before and after running training sessions with instructions.[28] When runners land on their heel, there is a spike in vGRF known as the impact transient, followed by a small decrease as the runner rolls forward onto their toes. There is then a second peak during push off. When runners adopt a forefoot strike pattern, there is only one peak, which may be overall slightly higher than the two peaks produced during heel strike, but average vGRF may be less.[29-31]

It is important to also note how the typical runner transitions from a traditional running form to a midfoot, forefoot, or Chi running style. Running coaches who teach a Chi or Pose running style remind their runners that they should be feeling gravity pulling them forward as they run and that their strides should feel like a controlled fall forward as opposed to an active attempt

to step forward in front of the body. Techniques are taught to promote landing softly on the fore-foot to midfoot with the ankles, hips, and shoulders in alignment resulting in an overall forward trunk lean posture and higher cadence. Other instructions along with the use of metronomes can be used to maintain an increased cadence from a preferred cadence. Lenhart et al.[32] found that a 10% increase in cadence leads to decreased patellofemoral stress, peak vGRF, and braking impulse. Thus, a change in cadence may be an important variable to adjust when re-training runners to run in this style. External focus training cues such as "imagine a plate on top of your head" or "run as though a rope is pulling you forward from your chest" are other examples of cues that may elicit greater learning and quicker progression to automaticity. Chi or Pose running workshops involve several hours of coaching, practice, and verbal and video feedback in addition to months of personal practice in order to achieve enough forward trunk lean and a consistent fore-foot strike pattern.[3] The differences in training between a Chi running workshop and our study may help account for the lack of significant changes shown in vGRF for any condition across time: Our runners ran for less than 10 miles per week, practiced this method for one month, and received no feedback or critique on their running style other than receiving two simple internally focused postural cues.

While lack of feedback may be a limitation, it is also common for runners to not have access to feedback during running. It should be noted that, among both conditions of running speeds, participants demonstrated gradually lower peak vGRF as the training progressed, which may reflect a natural learning curve upon response to a novel task. People generally perform more efficiently and correctly with increased comfort, time, and practice. Future studies should focus on types of feedback that can be incorporated into trials to induce a more significant change in running form.

As discussed in the introduction, there is agreement in the research regarding the kinematic differences between rearfoot strike and midfoot or forefoot strike runners. The research says that rearfoot strike running results in higher vGRF loading rates, higher maximum braking forces, and a greater number of impact transients. However, the findings of Arendse et al.[11] and Cheung and Davis[17]disagree with Goss and Gross[3] in that the former authors suggest that midfoot or forefoot strike patterns result in less peak vGRF on every foot strike, while the latter authors conclude that loading rates, impact transients, and maximum braking forces are the outcome variables that change based on foot strike pattern and not peak vGRF. Many authors agree furthermore that impact transients, loading rates, and braking forces are likely the variables that can be changed in running form in order to place less stress in high stress joints such as the patellofemoral joint. Therefore, data of vGRF loading rate and/or impact transient will need to be analyzed in future studies in order to give a more thorough answer as to whether impact can be decreased after receiving cues or training instruction.

There are also several other limitations to note when interpreting this data. Although instructions were deemed "simple", runners may easily interpret the cues in their own way and adjust their running form accordingly. The two instructions are both internally focused, guiding participant's attention to their own body movements. This may not be able to elicit maximal learning capacity and may actually interfere with movement automaticity.[33] Hence, a more externally focused instruction could facilitate more significant change. Secondly, typical running programs or progressions used to alter form are usually longer than 4 weeks with a great deal more feedback during that time, such as ChiRunning and the Pose Method. A study comparing the Pose Method to traditional heel strike running showed smaller vGRF loading rate and less horizontal braking when runners adopted the method.[34] Other studies have ranged from 5 days

with 1.5 hours of one on one training each day to 8 week program of 20 training sessions to one year long studies.[11, 16] The time the participants were allowed to alter their running form in our study may not have been long enough to produce significant change in peak vGRF. Finally, it should be noted that most participants began this study already having slight forward trunk posture before receiving any postural instruction. Before instruction, our participants ran with a mean trunk flexion angle of 6.69 degrees during the self-selected condition and 6.78 degrees when running at 2.5 m/s. It may be difficult to adopt an increased trunk angle during running if the subject was already running with a forward trunk angle posture. Future studies should analyze whether greater increases in forward trunk lean can be elicited in individuals who begin the study with a neutral or even extended posture. Other studies are needed in order to identify new attentional focus instructions which cannot be misinterpreted and create self-feedback to the runners so they are away of how they may be altering their running form. This will also identify other types of attentional focus, such as internal or external, that will promote better retention of running form reeducation. The results of this study will inform clinicians concerning impact forces, muscle activation, and foot strike pattern that will lead to a better understanding of how to decrease the prevalence of running related injuries using simple postural cues.

CONCLUSION

Simple postural instruction can help alter a person's running form with more trunk flexion. Peak vGRF was not significantly changed over the 5-week study period. Risk of injury may be reduced for runners by increasing trunk flexion angle and adopting a forefoot strike pattern.

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<u>CURRICULUM VITAE</u>

Casey U. Gray
8475 Holiday Lane
Reno, NV 89511
graycu618@gmail.com
(775) 772-9714

Education

2014-2017   ***UNIVERSITY OF NEVADA, LAS VEGAS***   **Las Vegas, NV**

- Doctor of Physical Therapy (3.51 GPA)

2009-2014   ***UNIVERSITY OF NEVADA, RENO***   **Reno, NV**

- Bachelor of Science in Biochemistry and Molecular Biology (3.44 GPA)
- Four year pole vaulter on Division I Track and Field Team

Experience (Clinical Internships)

2017   ***PHYSICAL THERAPY PARTNERS OF NEVADA***   **Reno, NV**

- Treated patients in the outpatient setting for 12 weeks

2016   ***REHAB CARE***   **Auburn, CA**

- Treated patients in the skilled nursing and rehab setting for 10.5 weeks

2016   ***SIERRA NEVADA VA HOSPITAL***   **Reno, NV**

- Treated patients in the acute care and ICU setting for 11 weeks

2015   ***RENO SPORT AND SPINE***   **Reno, NV**

- Treated patients in the outpatient setting for 6 weeks

Employment

2013-2014   ***CUSTOM PHYSICAL THERAPY*** (PT Technician)   **Reno, NV**

- Assisted patients through their exercise programs from multiple PT's
- Completed front desk work including scheduling and billing

Research

2015-2017   ***CAN SIMPLE POSTURAL INSTRUCTIONS MODIFY RUNNING FORMS IN RECREATIONAL RUNNERS?***

- Student Investigator
- Completed data reduction and analysis
- Participated in writing of scientific research paper
- Presented this research as part of a poster presentation at CSM 2017

Professional Development

2014-2017   ***PROFESSIONAL CONFERENCES AND COURSES ATTENDED***

- Combined Sections Meeting 2016, and 2017
- UNLV distinguished lecture series 2014-2015
- Therapeutic Neuroscience Education: Adriaan Louw 2015, 2016
- Member of APTA since 2014

Ian D. Tracy
8110 W. Courier St.
Boise, ID, 83714
theiantracy@gmail.com
(208) 949-5442

Education

2014-2017	*UNIVERSITY OF NEVADA, LAS VEGAS*	**Las Vegas, NV**

- Doctor of Physical Therapy (3.60 GPA)

2013-2014	*COLLEGE OF WESTERN IDAHO*	**Caldwell, ID**

- Pre-requisite classes for UNLV PT program (3.60 GPA)

2007-2011	*UNIVERSITY OF IDAHO*	**Moscow, ID**

- Bachelor of Science in Wildlife Resources (3.57 GPA)

Experience (Clinical Internships)

2015	*REHAB AUTHORITY*	**Eagle, ID**

- Treated patients in the outpatient setting for 6 weeks

2016	*ST. LUKE'S HOSPITAL*	**Meridian, ID**

- Treated patients in the acute and ICU setting for 11 weeks

2016	*ST. LUKE'S ELKS REHAB HOSPITAL*	**Boise, ID**

- Treated patients in the rehab setting for 10.5 weeks

2017	*BOISE VA MEDICAL CENTER*	**Boise, ID**

- Treated veterans in the outpatient setting for 12 weeks

Employment

2015-Present	**Camp Rhino and CrossFit Station**	**Henderson, NV and Boise, ID**

- Coach group CrossFit classes and weight lifting technique

Research

2015-2017	*CAN SIMPLE POSTURAL INSTRUCTIONS MODIFY RUNNING FORM IN REC-REATIONAL RUNNERS?*

- Recruited and performed testing on study participants
- Performed necessary data analysis
- Assisted in writing scientific research paper
- This research was presented as a poster presentation at CSM 2017

Professional Development

- Medical Minds in Motion IASTM level 1 certification March 2017
- Attended Combined Sections Meeting 2015, 2017
- Attended UNLV distinguished lecture series 2014, 2015
- Attended Therapeutic Neuroscience Education lecture: Adriaan Louw 2015, 2016
- Member of APTA since 2014
- Level 1 CrossFit certified instructor

Personal

- Proficient in Microsoft Word, PowerPoint, and Excel
- Enjoy sports and outdoor activities such as hunting, fishing, and mountain biking

Matt Poggemiller
1392 Jordyne St.
Fairbanks, AK 99701
mattpoggemiller@gmail.com
801-455-5874

Education

2017	*UNIVERSITY OF NEVADA, LAS VEGAS*	**Las Vegas, NV**

- Doctor of Physical Therapy

2009	*UNIVERSITY OF ALASKA, FAIRBANKS*	**Fairbanks, AK**

- Bachelor of Science, Anthropology

Clinical Experience, Student Physical Therapist

2017	*SELECT PHYSICAL THERAPY*	**Round Rock, TX**

- Treated veterans in the outpatient setting for 12 weeks

2016	*VA MEDICAL CENTER*	**Salt Lake City, UT**

- Treated patients in the acute and ICU setting for 10.5 weeks

2016	*MOUNTAIN VIEW HOSPITAL*	**Las Vegas, NV**

- Treated patients in the rehab setting for 11 weeks

2015	*COMPREHENSIVE PHYSICAL THERAPY*	**Henderson, NV**

- Treated patients in the outpatient setting for 6 weeks

Research

2015-2017	*CAN SIMPLE POSTURAL INSTRUCTIONS MODIFY RUNNING FORM IN REC-REATIONAL RUNNERS?*

- Student Investigator
- Performed analysis of running form using motion capture software
- Analyzed and reported data in research paper
- Presented poster at CSM 2017

Professional Development

- Combined Sections Meeting 2016-2017
- UNLV distinguished lecture series, 2014-2016
- Therapeutic Neuroscience Education, Adriaan Louw, 2015-2016
- APTA member since 2014, Orthopedic Section member since 2015, Sports Section since 2016

Employment

2010-2014	**SWCA Environmental Consultants**	**Salt Lake City, UT**

- Field Manager/Staff Archaeologist: responsible for management of archaeological technicians during field survey and excavation
- Perform and report on lab analysis of artifacts
- Coordinate and monitor construction activity over or near significant archaeological sites

2006-2009	**UAF Institute of Arctic Biology Student Worker**	**Fairbanks, AK**

- Fed and cared for research animal populations including lab and arctic mammals
- Assisted with year round maintenance of Large Animal Research Station grounds and facilities.
- Performed other tasks as needed within the Institute of Arctic Biology