EFFECTS OF VISUAL GAIT-RETRAINING ON DIFFERENT RUNNING CONDITIONS AND SPEEDS

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In running athletes suffer a certain amount of injuries in a given year. Gait-Retraining therefore has been a proposed method to decrease impact loads in runners. Consequently, the purpose of this study was to confirm the effectiveness of gait-retraining, observe kinematic changes and establish transfer between overground (OG) and treadmill (TD) running as well as different velocities. Results confirmed that gait-retraining can reduce tibial impact shock. This was found during TD running (pre/post) across 3 different speeds with lower effect in OG running. Kinematics changes were found in footstrike (TD and OG), ankle (TD) and trunk (TD) angles. To increase transfer effects, we should poof new methods for motor learning and/or improve the devices for feedback training in overground running

KEYWORDS: Tibial shock, overuse injuries, gait-retraining, transfer, different velocities

INTRODUCTION: Running is one of the most common and popular forms of exercise. Despite numerous health benefits, running-related injuries are a common occurrence with an incidence rate ranging from 18.2% - 92.4% (Lopes et al., 2012). Although identified by researchers as multifactorial certain factors have been identified that are likely to contribute to running-related musculoskeletel injuiries (RRMI's). One of these factors are the amount of impact energy (impact shock) the lower extremity and body structures *repetitively* have to absorb during various strenuous training plans (Mercer et al.,2003). This is directly linked to the training frequency and volume of each runner (van Gent et., 2007). It was reported that greater instantaneous and average vertical loading rates as well as tibial impact accelerations exist in runners with a history of tibial stress fractures. Visual gait-retraining has been found to be a method to reduce (up to 50%) the tibial impact shock (PPA – peak positive acceleration) with the goal in mind to reduce the repetitive load runners experience at initial foot contact and subsequently decrease RRMI's (Crowell & Davis, 2011). Although evidence off decreased PPA after gait-retraining is encouraging, a lack of kinematic evidence still exists on how subjects decrease PPA during training. Also very limited information is present on how effects of gait-retraining transfer to different speeds and running conditions (TD vs OG).

Purpose of study: The purpose of the study was first to confirm if they can reduce PPA using GRF as the visual feedback parameter during a gait-retraining intervention, second to better understand what kinematic changes the runners undergo to accomplish this goal, thirdly to determine if the effect training effect carried over to different speeds and lastly establish the transfer effects between running conditions (TD vs OG).

Hypotheses: It is predicted that changes in kinematics and kinetics will be found between pre and post testing and different velocities after the 2-week gait-retraining program.

METHODS: 30 runners were screened for pure heel strikers. Due to time constraints only 8 recreational runners were chosen to participate in the study. Subjects were all experienced running on a treadmill, ran more than 16km p/week and were free from any injuries that eliminated them from running more than a week. Visual inspection was done to determine if each subject had a clear distinct impact transient in there force curve.

Gait-Retraining Intervention: Gait-retraining were conducted according to (Crowell & Davis 2011). Each subject had 8 training sessions (30 min session) with a rest day after every two days and two days rest after the 4 training session (2 weeks). No additional running was done during the intervention. Ground reaction force foot impact characteristics were given to each subject through a computer monitor screen in-front of each runner. Subjects were asked to *decrease* the initial impact transient through using 4 different assistive clues. For the first 4 sessions subjects received feedback at every second 5min interval for 5min. After 4 sessions 1min of feedback were taken away for each session at each 5min feedback interval.

Data Collection: Pre and Post variables (Table 1) were collected in both overground (OG) and treadmill (TD) conditions with each condition consisting of 3 different speeds. For treadmill data collection an instrumented running treadmill were used and for overground testing a large indoor running space with indoor running track. Running speeds were below preferred speed (BPS), preferred speed (PS) and above preferred speed (APS) (± 0.25m/s). Vertical ground reaction force data together with speed were used to determine foot contact and calculate stride cycle parameters (Table 1). Peak Positive Acceleration were collected with a Tri-axial accelerometer (1500Hz) positioned at the medio-distal part of the tibia (Noraxon 3D accelerometer sensor – 12g, USA). Acceleration data was filtered with a Low-Pass Butterworth filter with a Cut-Off frequency off 50Hz. Kinematic data were collected with a video camera (50Hz). For both over ground and treadmill testing the camera was placed perpendicular to the running direction. For treadmill pre and post data collection 30 sec of data were collected for each speed after a 5 min warm-up with no rest between speeds. For overground 5 running trials p/speed were collected while continuously running in a circle.

Data Analysis: Kinematic video data were analyzed using SimiMotion Video Analysis software (Simi Reality Motion Systems GmbH). All data presented is at initial foot strike. PPA were determined using a custom written MATLAB (Mathworks USA) program. PPA were recorded as the first maximum peak (axial axis) after foot contact. Basic paired T-Tests were used to compare differences between pre/post conditions and OG vs TD conditions at all the 3 different speeds indicated above. Alpha level was set at $p = 0.10$. The averages for 5 trials OG and 5 steps TD were used for analysis

RESULTS: No significant difference were found in velocity and cycle parameters during pre/post and TD vs OG except for increase stride frequency in the preferred speed during OG running in pre/post testing. For treadmill running PPA indicated significant decrease during pre/post analysis across all velocities for TD running. For kinematic data pre/post testing results showed a significant difference in foot strike (↓), and ankle angle (↑) for BPS and APS and trunk angles for all velocities in treadmill running. For overground running we only found a significant reduction in PPA and only APS. Kinematic results also show a significant decrease in footstrike angle during pre/post OG running across all speeds. Comparing surface conditions (OG vs TD) revealed a significant decrease in PPA during APS (Pre) and BPS (Post). When comparing TD vs OG, kinematic results indicated significance in foot strike (↓), hip (↑) and trunk (↓) angles across all 3 speeds during post testing.

DISCUSSION: Comparing previous research (Crowell & Davis 2011) with the current study it was found that subjects could also decrease impact load after a 2-week gait-retraining intervention during TD running. PPA showed a significant decrease in pre/post testing and although not reported in this study loading rates were also significantly decreased. Past studies indicated that transfer effects are present from treadmill (training) to overground testing. That being said the current study indicated a transfer to only 1 speed (APS) in overground running. Because runners do not keep one exact constant speed during a complete training session, we looked at different speeds and saw that gait-retraining effects transferred well across all 3 speeds during pre/post testing in TD running but not OG running. It was encouraging to see that athletes were able to reduce PPA at all 3 speeds pre/post after the training intervention was conducted at only PS. The current study provides valuable information to the literature regarding speed transfer in gait-retraining since current data on speed transfer are limited. From a general point of view more significant differences were found in treadmill pre/post testing compared to overground. Due to limited data available in the research it was difficult to conduct a comprehensive comparison to the current study. Nevertheless, it was observed for kinematics that athletes mostly used initial foot strike patterns (towards mid/forefoot), ankle and trunk angle (more upright position) to reduce impact loads. This observation was only found in TD running except for footstrike angle which significantly changed in OG running as well. A transfer across all speeds for kinematic variables were found in treadmill running but again not in OG running with the exception of foot strike angle. No significant difference was found in

Table 1: Indicates the average and standard deviation (Stdev) values between pre and post testing for all 3 speeds tested. “Sig” columns indicate whether there was a significant difference. p=0.10. “Acc” = Acceleration, “Stdev” = Standard Deviation, “IC” = Initial Contact. “LLN” = Leg Length Normalized

	Overground (OG)									**Treadmill (TD)**								
	Below Preferred Speed			**Preferred Speed**			**Above Preferred Speed**			**Below Preferred Speed**			**Preferred Speed**			**Above Preferred Speed**		
	Pre	**Post**	**Sig**	**Pre**	**Post**	**Sig**	**Pre**	**Post**	**Sig**	**Pre**	**Post**	**Sig**	**Pre**	**Post**	**Sig**	**Pre**	**Post**	**Sig**
Stride Frequency	1.409	1.431		1.407	1.442	X	1.424	1.257		1.404	1.406		1.454	1.411		1.450	1.433	
Stdev	0.100	0.111		0.094	0.102		0.099	0.561		0.111	0.116		0.104	0.091		0.145	0.144	
Contact Time	0.229	0.227		0.229	0.224		0.222	0.193		0.235	0.234		0.234	0.225		0.218	0.206	
Stdev	0.027	0.032		0.033	0.035		0.027	0.097		0.030	0.021		0.028	0.028		0.030	0.027	
Flight Time	0.128	0.124		0.128	0.124		0.131	0.100		0.124	0.124		0.111	0.130		0.130	0.147	X
Stdev	0.020	0.019		0.021	0.023		0.018	0.054		0.020	0.038		0.032	0.031		0.043	0.034	
Stride Length - LLN	2.453	2.489		2.622	2.589		2.697	2.284		2.438	2.435		2.558	2.635		2.778	2.816	
Stdev	0.285	0.341		0.291	0.318		0.311	1.051		0.276	0.272		0.295	0.318		0.320	0.369	
Peak Postive Acc	9.837	8.734		10.031	9.091		10.737	7.930	X	10.148	7.161	X	11.293	8.537	X	13.112	9.563	X
Stdev	3.051	2.505		3.093	2.601		3.098	4.298		3.797	2.827		3.867	2.911		4.788	3.449	
Stiffness	25.469	26.381		25.674	26.958		26.495	23.632		24.831	24.884		25.805	26.337		28.259	29.592	
Stdev	6.420	6.997		7.308	7.391		6.686	12.798		6.873	5.768		6.056	7.737		8.731	9.001	
Foot Strike Angle - IC	10.938	-0.678	X	12.128	0.585	X	10.103	0.203	X	2.665	-10.596	X	3.238	-0.620		4.158	-9.567	X
Stdev	5.489	6.166		6.937	7.339		8.920	6.830		9.688	6.181		10.531	14.168		10.789	8.239	
Ankle Angle - IC	97.988	124.980	X	97.383	122.982		100.775	109.341		118.157	127.513	X	117.706	120.291		117.572	126.950	X
Stdev	43.419	9.821		43.248	10.809		45.199	49.587		6.791	8.996		8.010	9.888		7.043	9.165	
Knee Angle - IC	147.181	166.309		146.170	166.686		145.791	142.548		168.898	166.636		168.880	167.717		167.955	166.093	
Stdev	65.074	3.040		64.507	4.307		64.381	63.000		3.461	4.986		4.347	5.084		5.124	5.898	
Hip Angle - IC	133.134	154.415		131.771	154.572		131.664	132.802		156.735	161.694		155.833	160.428		155.64	160.074	
Stdev	58.905	3.038		58.373	4.022		58.190	58.667		4.998	3.088		3.978	4.023		4.173	3.939	
Trunk Angle - IC	5.681	5.309		6.224	4.949		5.879	4.488		4.750	-2.746	X	5.173	-1.469	X	5.148	-3.376	X
Stdev	3.534	3.447		4.007	4.338		3.405	5.240		3.125	2.939		2.856	5.435		2.249	3.722	

knee or hip angles. Compared to the literature athletes also used a more midfoot/forefoot footstrike angle to reduce impact loads. It was expected that runners might adjust their knee angle and stiffness when moving to a more midfoot/forefoot strike, but that was not the case. It has also been shown that stride characteristics (example – stride frequency (SF) are linked to footstrike patterns (Mercer et al., 2003). This was interestingly not found in the results of the study except for two conditions, PS OG running and APS TD running. Participants showed a significant change in trunk angle in treadmill pre/post testing. This was also the case when comparing overground vs treadmill running which indicates that subjects used upper body posture as a method to assist footstrike pattern in reducing PPA. When looking at treadmill vs overground comparisons (pre/post) we see as expected not much significant differences among parameters. That being said a significant difference were again found in footstrike and trunk angles as well as hip angle in two of the speeds during post testing. A significant trend in the treadmill pre/post versus no trend in overground running might explain the significance difference found in hip angle during TD vs OG post testing.

CONCLUSION: Overall, results indicated kinetic (PPA) and kinematic changes between pre/post testing in treadmill (TD). A transfer effect was found across all velocities in treadmill running with a lower transfer to overground running. Although our study is limited by a small sample size, we could show some transfer effects for velocity and running conditions. Coaches should understand that athletes need gait-retraining effects both to transfer across speeds and running conditions in order effectively reduce loads over a period of time. Coaches and trainers should also focus on footstrike patterns and body upper trunk posture when conducting gait-retraining. It’s clear that more research needs to be done relative to transfer effects. Based on the results it is suggested that coaches and scientific studies should focus on conducting gait-retraining in a more natural environment to eliminate transfer problems. New technology (wearable sensors) can be used do so, example an audio feedback sensor.

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