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Backward Walking: A Possible Active Exercise for Low Back Pain Reduction and Enhanced Function in Athletes

JANET DUFEK[1], ANTHONY HOUSE[2], BRENT MANGUS[3], GEOFFREY MELCHER[1], JOHN MERCER[1]

[1]Department of Kinesiology and Nutrition Sciences, University of Nevada, Las Vegas, NV, USA, [2]University of Pittsburg, Human Performance Research Center, Fort Campbell, KY, USA. [3]Texas A&M, Commerce, TX, USA

ABSTRACT

Dufek JS, House AJ, Mangus BC, Melcher GG, Mercer JA. Backward Walking: A Possible Active Exercise for Low Back Pain Reduction and Enhanced Function in Athletes. **JEP**online 2011;14(1):17-26. Specific pathologies that associate with low back pain (LBP) challenge athletic trainers and other healthcare professionals with techniques to treat stricken athletes. The primary purpose of this study was to investigate the effectiveness of a backward walking exercise program in alleviating LBP and enhancing function in athletes. A secondary purpose was to identify which aspects of backward walking performance may be beneficial to the alleviation of LBP. Subjects, who included NCAA Division I athletes experiencing LBP (n = 5) and healthy, active individuals not experiencing LBP (n = 5), performed a pre-test, 3-week intervention of backward walking, and post-test. Low back range of motion, stride parameters, shock attenuation and pain scores were measured and/or recorded during each test session. Group results for 2 (group) x 2 (time) ANOVAs identified significant (p < 0.05) differences between groups and time for all stride parameters. The LBP group exhibited significantly greater sagittal plane low back motion and lesser coronal plane motion versus the healthy group. Single subject analyses identified unique participant responses with most reducing shock attenuation (17.2 ± 5.9%), and increasing sagittal (3.9 ± 1.6 deg) and coronal (5.0 ± 4.2 deg) plane range of motion following the intervention while one participant elicited responses that were opposite. Results suggest that backward walking may reduce LBP and enhance function for athletes. Further investigation is warranted.

Key Words: Athletic Rehabilitation, Retro Walking, Back Pain, Spine

INTRODUCTION

The relationship between mechanisms of LBP and specific pathologies remain elusive. It has been reported that 80% of all patients who exhibit symptoms associated with LBP do not produce diagnostic tests or imaging results that are linked to specific pathologies (7). This fact alone clouds the therapeutic management prescription to decrease or eliminate LBP. However, practitioners have become increasingly more successful at managing LBP by focusing their treatments based upon symptomatology (11).

The number of collegiate athletes who experience LBP ranges between 1% to greater than 30% (4,18,19). Bountiful radiographic evidence states that vertebral disc degeneration is higher in athletes than in non-athletes (4), yet no known cause-effect relationship has been advanced. Sports which consist of repetitive back hyperextension motion such as diving, gymnastics, and wrestling have been associated with higher rates of spondylolysis (4,10,20). But, the occurrence of these vertebral stress fractures has not been documented to be higher in athletes versus non-athletes.

In many cases, LBP can be highly debilitating, leading to reduced or total elimination of training for athletes. When that happens, their focus shifts from competition to rehabilitation. Varying degrees of intensity of LBP coupled with individual pain tolerance levels can allow some athletes to continue to train while managing LBP with non-surgical or non-physician directed therapy. Effective modalities to reduce the limited training and downtime associated with LBP are continuously being studied by athletic trainers and other healthcare providers.

One of these modalities is backward walking and/or running, which has been shown to have potential benefits kinematically (2). Previous research by Masumoto et al. (13,14) has shown that backward walking in a water environment increases core muscle activity and metabolic cost versus walking forward in the same environment. In addition, Whitley and Dufek (21) documented an increase in the flexibility of the hamstrings following a backward walking intervention. Despite these studies, backward walking, with respect to LBP, has not received a thorough scientific analysis. Therefore, we sought to expand on these findings and questioned the efficacy of backward walking as a possible modality for the treatment of LBP in athletes.

Many researchers and clinicians have suggested that an increase in core strength and improvement in pelvic alignment are key to resolving and/or avoiding LBP (4,9,10). Similarly, from an anatomical perspective, there is the logical rationale for possible success of a backward walking intervention (8,17). During backward walking, the typical heel-strike associated with ground contact is eliminated because the toe contacts the ground first (2). The kinematic difference has the potential to manifest itself in a more anteriorly aligned pelvis. This may open up the facet joints in the vertebral column and, therefore, help in alleviating the pressure and associated LBP.

Although supported by anatomical logic, the kinematic pattern produced when walking or running backwards has yet to be empirically validated. Thus, the primary purpose of this study was to investigate the effectiveness of a backward walking exercise program in the alleviation of LBP and the enhancement of function in athletes. A secondary purpose was to identify which aspects of backward walking performance may be beneficial to LBP. We sought to determine the effectiveness of backward walking as a therapeutic exercise modality to alleviate LBP through the investigation of shock attenuation (impact dissipation) characteristics and pelvic movement among people walking backward. We hypothesized that the incorporation of backward walking as a clinical intervention

would reduce the athletes' self-reported LBP measures via a modification of the shock attenuation charactistics and low back/pelvic movements displayed during backward walking.

METHODS
Subjects
Five NCAA Division I athletes currently experiencing LBP (21.2 ± 5.1 yrs, 172.8 ± 7.3 cm, 68.5 ± 7.7 kg) and five active, healthy collegiate individuals free from LBP (21.6 ± 1.5 yrs, 168.1 ± 7.0 cm, 63.0 ± 0.6 kg) volunteered to participate in this study. Inclusion criteria for the LBP group was stipulated as having experienced LBP some time in the past 8 months and currently electing to allow the pain to resolve without physician involvement (after consultation with the team physician) for the present time and the duration of the study. In addition, any volunteers who presented with acute lower extremity injuries or abnormalities (including leg length differences > 2 cm, as measured non-invasively with a tape measure) were excluded from the study. All subjects granted written consent in accordance with policies established for the Protection of Human Subjects at the affiliated university.

Procedures
Pre- and post-testing data consisted of first subjectively reporting a LBP pain measure (LBP group only). All volunteers then practiced walking backwards on a treadmill (Precor, Model C966) prior to data collection. When the subjects reported they felt comfortable walking backwards without the use of external support (e.g., grasping the treadmill rails), the preferred comfortable backward-walking velocity was established. This was done by blinding the subject to the treadmill speed and progressively increasing the speed until the subject indicated that the speed was too fast to walk. The subject was then instrumented with two lightweight uniaxial accelerometers (PCB Piezotronics Inc., Model 352C68). One was secured to the distal anterior surface of the right tibia and the other to the midpoint of the forehead, which was secured with an adjustable headpiece (Figure 1). A biaxial electrogoniometer (Biometrics, Model SG150) was secured externally to the low back, spanning T12-S2 (Figure 2). The subject then walked backwards on the treadmill for 9 min, with data obtained synchronously (1000 Hz) using Bioware data acquisition software (Kistler, version 3.21) for 45 sec during the sixth min of the walk (15).

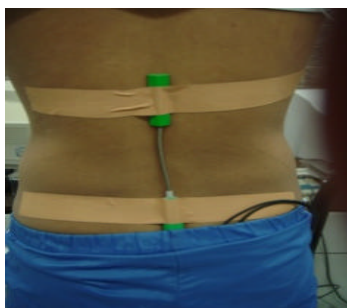Figure 1. Headgear Used to Secure Accelerometer

Figure 2. Position of Electrogoniometer Spanning the Low Back

Intervention
Following the pre-test, participants completed 3 weeks of supervised backward walking on a treadmill for 15 min/day, 3 days/week, freely controlling walking velocity. Following completion of the intervention, all subjects were post-tested following the same procedures as the pre-test with velocity established in the same fashion as during the pre-test. Walking velocity was blinded to both the

subjects and the research associate during practice and both testing sessions until completion of the walking conditions.

Statistical Analyses

Ten strides per subject-condition were extracted from the continuous data sets using the tibial accelerometer time-history profiles to define each stride. Accelerometer and electrogoniometer data were filtered with a 4th order low pass Butterworth filter (20 Hz) using a custom laboratory program (MatLab version 6.1). Dependent variables (DVs) included walking velocity (Vel), subjective pain measure (P; LBP group only), shock attenuation (SA: [1-(peak head acceleration/peak leg acceleration) x 100]), stride length (SL), stride rate (SR), sagittal plane range of motion (sROM) of the low back, and coronal plane range of motion (cROM) of the low back.

The mean values of the 10 footfalls per subject-condition-test session were utilized for subsequent 2 (group) x 2 (time) mixed model analysis of variance (ANOVA) procedures for each DV with significance established at p = 0.05. The P scores for the LBP group were evaluated using a correlated t-test. Owing to the clinical nature of the investigation, we also sought to explore results of the LBP subjects only on a single-subject statistical basis using the Model Statistic technique (1,3,5) for SA, sROM and cROM to determine the potential systemic kinetic changes or low back kinematic changes. The exploratory nature of this study as well as access to subjects who satisfied the inclusion criteria limited sample size.

RESULTS
Group Results

Exemplar acceleration-time and sROM-time histories are presented in Figures 3 and 4, respectively. The group descriptive data are summarized in Table 1. There were no significant group x time interactions for any of the DVs. A significant decrease (p = 0.004) in P for the LBP group was observed following the intervention. Significant group differences were observed for Vel (p < 0.0001), sROM (p = 0.0067), cROM (p = 0.0487), SL (p = 0.0002), and SR (p = 0.0012); while significant time effects (i.e., pre vs. post) were observed for Vel (p = 0.0004), SL (p = 0.0110), and SR (p = 0.0213). SA was not difference nor were there any significant changes in low back kinematics across time.
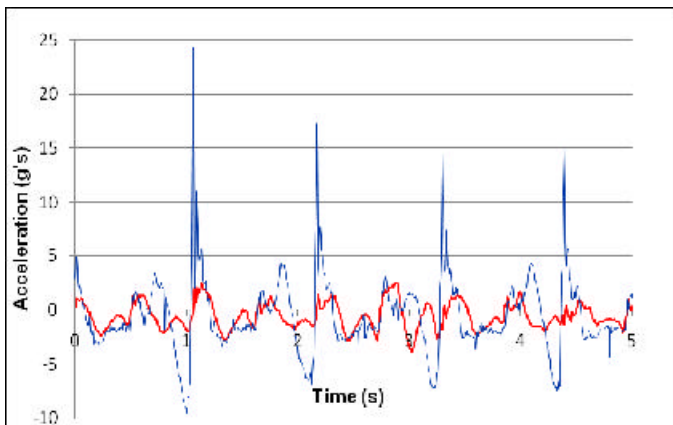

Figure 3. Exemplar Acceleration-Time History
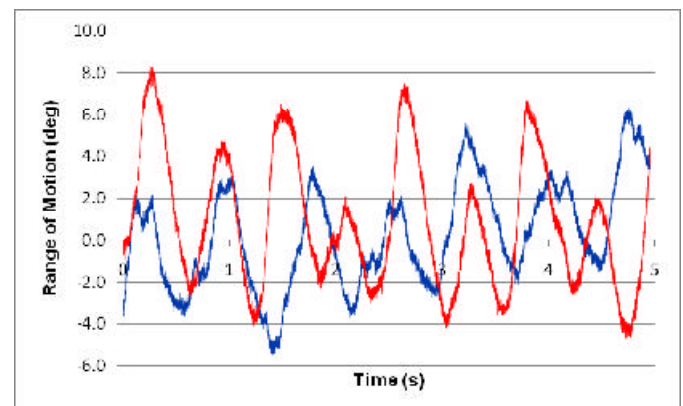For the Leg (blue) and Head (red)

Figure 4. Exemplar sROM-Time History for
Pre-Intervention (blue) and Post Intervention (red)

Table 1. Descriptive results (mean ± standard deviation) by group-time and pre-post percent change.

DV (units)	Healthy			LBP		
	Pre	Post	% change	Pre	Post	% change
Pain (integer)	Na	na	na	3.2±1.3	2.0±1.0	-37.5
Velocity (m/s)	0.54±0.04†	0.87±0.21*†	61.1	1.14±0.13†	1.38±0.11*†	21.1
SL (m)	0.79±0.13†	1.08±0.14*†	36.7	1.22±0.08†	1.36±0.15*†	11.5
SR (hz)	0.69±0.07†	0.81±0.10*†	17.4	0.94±0.05†	1.02±0.13*†	8.5
SA (%)	67.3±26.0	69.8±17.3	3.7	64.5±11.6	52.0±19.9	-19.4
sROM (deg)	4.6±2.3†	6.1±1.8†	32.6	11.0±1.6†	12.6±6.0†	14.5
cROM (deg)	14.3±4.9†	18.8±5.9†	31.5	9.7±2.3†	13.1±7.4†	35.0

See text for abbreviations; % change = [(post-pre) / pre] * 100]; na = not applicable. *Significant difference (p<0.05) between conditions (Pre vs. Post). †Significant difference (p<0.05) between groups (Healthy vs. LBP).

Single-Subject Results

Owing to the clinical nature and interest of this investigation, the Model Statistic (1,3,5) single-subject analysis procedure was used to investigate SA and low back motion characteristics for the LBP subjects only. A significant reduction in SA (7.8-24.0%) following the intervention was observed for four of the five subjects (p < 0.05). There was a significant increase in sROM (4-6 deg) and cROM (3-12 deg) observed for three of the five participants following the intervention (p<0.05). Single-subject results are summarized in Table 2.

Table 2. Model Statistic Single-Subject Results for LBP Participants.

Subject	Pre (10 trials)	Post (10 trials)	Observed Difference	Critical Difference*
SA (%)				
- **S1**	54.0±9.8	34.1±7.7	19.90	7.84‡
- **S2**	81.0±7.8	64.1±10.5	16.99	8.18‡
- **S3**	64.7±6.9	56.8±9.9	7.86	7.55‡
- **S4**	52.2±10.7	29.2±11.5	24.05	9.86‡
- **S5**	69±3.9	73.0±6.3	6.37	4.65†
sROM (deg)				
- **S1**	12.9±1.4	18.4±2.2	5.47	1.65†
- **S2**	10.3±2.1	15.0±1.9	4.75	1.83†
- **S3**	8.8±1.4	10.0±2.5	1.16	1.81
- **S4**	12.2±2.1	16.2±1.3	4.01	1.56†
- **S5**	10.8±1.7	3.3±0.6	7.51	1.16‡
cROM (deg)				
- **S1**	12.9±0.9	24.9±2.0	11.84	1.37†
- **S2**	6.8±1.1	7.1±1.9	0.32	1.38
- **S3**	12.1±1.3	16.9±1.2	4.76	1.14†
- **S4**	8.4±2.0	11.7±1.5	3.31	1.54†
- **S5**	9.2±1.7	6.0±1.4	3.21	1.38‡

*Critical difference is the minimum value, based upon individual subject number of trials and variability necessary to obtain statistical significance at the criterion value (a=0.05). For a detailed description, see Bates et al. (3). †Significant (p<0.05) increase. ‡Significant (p<0.05) decrease.

DISCUSSION

The purpose of this study was to investigate the effectiveness of a backward walking exercise program in alleviating LBP in athletes. Low back pain presents a challenge for the clinician, and it is thought to be best managed by categorizing or matching treatments to particular symptomatology (7,9). There was no attempt to categorize specific LBP etiology or to control or even suspend other forms of treatment modalities. Despite these limitations, results identified significant gait-related changes for both groups following a backward walking intervention. Specifically, both groups increased velocity, stride parameters, and low back ROM following 3 weeks of backward walking exercise. It appears that the presence of LBP did not interfere with the ability of participants to adapt to the actions of backward walking. Both groups achieved greater walking velocity with a greater percent increase in SL versus SR.

In order to explore the possible relationship between SL and sROM, we examined the ratio of percent change in sROM:SL. This ratio was 0.89 for the healthy (control) group and 1.26 for the LBP group, possibly suggesting that the increased SL was achieved with a great change in sROM for the LBP group versus the healthy group. While this point of view cannot be substantiated in the present work, it could be addressed by exploring the contribution of back and postural muscles to SL changes following backward walk training. Importantly, all LBP subjects reduced self-reported P and over half significantly increased low back range of motion. This finding suggests, as has been previously reported (21), that backward walking improves low back flexibility as expressed in the current study by increased cROM and sROM.

The changes exhibited by the control group (Table 1) were not anticipated. It appears that backward walking was a novel task. As a group, they adopted a more potentially challenging gait pattern (e.g., faster walking velocity, longer SL, increased low back range of motion) after the training program. The LBP group walked faster than the controls during pre- and post-training. Considering the high level of training necessary for NCAA Division I athletes and their exposure to backward walking during training, this is not surprising. Also, given that many mechanical parameters increase with greater velocity when walking forward (e.g., impact magnitude), it appears that the LBP group had augmented ability to increase demand following the training program as evidenced by increased backward walking velocity and SL, both in an absolute sense and in performance values being greater than the control (healthy) group.

During backward walking, hip extension and knee flexion are greater than in forward walking (22). Greater hip extension and a concomitant extension of the lumbar spine increasingly load the facet joints opening up the disc space, causing a reduction in compressive loads to the intervertebral discs (9). This unloading of the discs may be a mechanistic outcome of backward walking by way of an increase in hip extension, as evidenced by the decreased P scores reported by the LBP group. As well, increased loading of the facet joints may explain the increase in low back ROM observed for both groups in the current study sample.

Furthermore, Leteneur et al. (12) examined the effects of natural trunk inclination (e.g., forward or backward lean) on low back joint moments during forward walking. They reported peak flexor moments at L5 during specific phases of support that were 1.4 times greater for the backward inclined group versus the forward inclined group. It is not known if this result would change if the direction of walking is reversed. Leteneur et al. (12) further concluded that differential walking patterns existed for the two groups, specifically that the forward inclined group utilized hip muscles throughout the stance phase while backward inclined individuals relied more on a strong hip flexor

moment at takeoff. Bates et al. (2) identified a more erect trunk posture at touchdown and takeoff during backward versus forward running. Viewed conservatively in light of the present results which indicated greater sROM for both groups following the backward walking intervention, the work by Leteneur et al. (12) and Bates et al. (2) lend support for the possible mechanism for LBP reduction during backward walking as being related to unloading of the discs via increased hip joint extension.

Single-subject analysis results provide additional insight into the effects of the intervention. A measure that captures a sense of how the body attenuates shock generated at impact due to foot contact with the ground is SA (16). It increases if the peak leg acceleration (LgPk) increases with no change in the head peak impact acceleration (HdPk) or if HdPk decreases with no change in LgPk. If both LgPk and HdPk change (increase or decrease), the interactive change will result in a specific, non-predictive change in SA. In the present study, all subjects demonstrated an increase in LgPk (average increase = 0.14 g's) and 4 of 5 participants also displayed an increase in HdPk (average increase = 0.23 g's), resulting in an average decrease in SA of 15% for the group. One subject (S5) who produced a decrease in HdPk also exhibited a significant increase in SA, which has been shown to be related to an increase in velocity in running (6,16). This increase in SA with running speed typically is the result of an increase in LgPk with no change in HdPk.

In the present study, the increase in backward walking velocity resulted in a decrease in SA for 4 of the 5 participants. LgPk did increase with increased backward walking velocity; however, it was coupled with a concomitant increase in HdPk, unlike results indicated for running. HdPk has been shown to remain relatively unchanged at about 1.0-2.0 g's during forward running (6,16). In the current study, both LgPk and HdPk increased with an increase in backward walking speed during the post-test for most participants, while HdPk values remained well below 1.0 g's (range = 0.39-0.74 g's). Interestingly, the individual with the increase in SA for the post-test (S5) exhibited the smallest increase (0.14 m/s) in backward walking velocity of all the subjects. This might suggest a different backward walking strategy (1) for this subject (S5) in order to accommodate the LBP as suggested by an observed reduction in sROM and cROM.

Single-subject kinematic outcomes also provided insight into possible kinematic adaptation strategies. Three subjects significantly increased sROM (average = 4.8 deg) while one subject (S5) significantly reduced sROM (7.5 deg). The same three participants also significantly increased cROM (average = 6.6 deg) while S5 significantly reduced cROM (3.2 deg). The intervention of backward walking appeared to significantly increase low back motion (flexion-extension and lateral bending) for three subjects, while also leading to a reduction in self-reported LBP. Again, S5 appeared to present a unique strategy of backward walking.

Current progression used by athletic trainers, clinicians, and other healthcare professionals to manage LBP consists of rest, ice, and stretching, followed by rest, heat, ultrasound, muscle stimulation and stretching. The next step would be the introduction of light exercises. Presently, there is a lack of integrated exercise in the progression. Perhaps backward walking can serve to fill that void and enhance recovery efforts.

Limitations of the study, including the small sample size, do not allow one to state definitively that backward walking only led to the observed outcomes of reduction in self-reported LBP, increased walking velocity, and increased low back range of motion (most subjects). No control was imposed upon the subjects relative to supplementary forms of treatment, with the exception of physician intervention. Screening was not performed to categorize symptomatology, as has been suggested (7,9). In addition, time itself may have contributed to the reduction in self-reported pain. Despite these

limitations and in light of the debilitating effects that LBP can produce for an individual, further study is indicated in regards to functional changes that may be elicited as a result of backward walking.

CONCLUSIONS

The primary purpose of this study was to investigate the effectiveness of a backward walking exercise program in alleviating LBP and enhancing function in athletes. A secondary purpose was to identify which aspects of backward walking performance may be beneficial to the alleviation of LBP. The results support backward walking to reduce pain and increase low back range of motion for athletes with LBP. Single-subject evaluation provides insight into mechanistic changes elicited by the intervention for specific individuals with LBP, including an increase in SL possibly accompanied by an increase in sROM. Clearly, additional research is warranted in this area. Investigations into the role of lumbar musculature in postural stability and dynamic function may be particularly insightful to further understand the potential relationship between backward walking and LBP reduction.

Address for correspondence: Dufek JS, PhD. Department of Kinesiology and Nutrition Science, University of Nevada, Las Vegas, NV, USA., 89154-3034. (702) 895-0702; janet.dufek@unlv.edu.

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