The Effectiveness of an Unstable Sandal on Low Back Pain and Golf Performance

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Objective: The objectives of this study were to assess the effect of unstable sandals on (1) low back pain (LBP) in golfers with undiagnosed moderate LBP, (2) static and dynamic balance, and (3) golf performance.

Design: This was a 6-week prospective study where subjects were randomized to a control group and an intervention group.

Setting: Baseline measurements were recorded in the Human Performance Laboratory.

Participants: Forty male golfers with nonspecific moderate LBP.

Intervention: The intervention group wore unstable shoes for 6 weeks, and the control group wore their regular golf shoes.

Main Outcome Measures: Low back pain, timed balance, and golf performance were assessed at baseline and at 6 weeks. Changes were compared through independent samples *t* tests.

Results: (1) There was a significant difference between groups in the change of perceived LBP scores in the laboratory (test group: −17.5/100 mm, control: −3.6/100 mm) and in the comparison of the first week entries to the last week entries recorded in logbooks (test group: −10.7/100 mm, control group: +2.6/100 mm). (2) There was no significant change in the static or dynamic balance times. (3) There was no significant change in golf performance between the intervention and control groups.

Conclusion: The results indicate that unstable sandals can be used to reduce moderate lower back pain in this population of golfers without negatively affecting performance.

Key Words: MBT, MASAI, footwear, balance, stability

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INTRODUCTION

Golf is a popular sport, with about 55 million participants throughout the world.[1,2] The pleasant natural environment and the health benefits of walking that are associated with golf have been identified as motives for participating in the sport.[2] Although golf may provide health and fitness benefits, the sport also seems to have certain injury risks.[3] The most common injury affecting the ability to play golf is low back pain (LBP).[4–6] A reduction of such pain would likely result in enhanced performance and increased pleasure. Thus, any strategy to reduce pain during a golf game is of interest.

There are many factors affecting LBP from golf including overuse and technique faults.[7,8] However, several studies have identified an association between golfers with LBP and weakness of the various trunk muscles that help stabilize the spine.[1,9,10] A commonly prescribed treatment for chronic LBP is exercise training to strengthen the muscles of the spine and improve postural stability.[11–13] Criticism of this intervention lies within the time commitments, equipment, and personnel requirements, which can lead to overall noncompliance.[14] Therefore, an optimal solution would be an effective form of exercise intervention that did not require a great deal of time or equipment. One proposal would be the use of an unstable shoe, which in essence would help train the stability muscles throughout the body during normal activities of daily living (ADL). An investigation into the use of an unstable sandal for this purpose was conducted by Michell et al.[15] The authors concluded that the addition of unstable sandals during training was an effective way to increase postural stability, one of the training goals in patients with LBP. This was concluded based on a decreased anterior–posterior excursion of the center of pressure after training in the unstable sandals.

A relatively new shoe by Masai Barefoot Technology (Hailey, Indiana) (MBT), which incorporates a rounded sole to increase instability in the anterior–posterior direction (Figure 1), has been marketed to consumers experiencing non-debilitating lower limb and spinal pain. Previous scientific investigation has shown that wearing the shoes for 6 weeks resulted in a significant reduction in the perception of knee pain in a population of subjects with moderate knee arthritis.[16] Based on these findings and those of Michell et al, one may speculate that wearing MBT sandals throughout the day may result in a reduction in the amount of LBP experienced after playing golf.

In addition to the potential health benefits of wearing unstable shoes for ADL, hitting golf balls while wearing the shoes may further enhance the specific stability muscles used

FIGURE 1. The unstable MBT sandal used as shoe intervention in this study. MBT, Masai Barefoot Technology.

during the swing motion. Balance and stability have been noted as important performance attributes among elite golfers.[17] During the downswing, a highly synchronized series of various joint loads and pressures are applied throughout the body. If these forces are misapplied, balance is lost triggering a subconscious process by the brain to regain balance while at the same time trying to effectively coordinate the downswing motion.[18] The end result is a loss of performance. Previous research has shown that using unstable training devices such as wobble boards[19] or unstable footwear[17] has a positive effect on balance control, which in theory could improve golf performance.

It would seem from the above that using an unstable shoe while practicing golf shots and during ADL may have a positive effect on reducing back pain and improving golf performance in a population of golfers suffering non-debilitating LBP. Thus, the purposes of this study were to assess the effect of an unstable shoe on (a) LBP in golfers with moderate nonspecific LBP, (b) static and dynamic balance, and (c) golf performance.

METHODS

This study has been approved by the University of Calgary's Conjoint Health Research Ethics Board. Forty male golfers with self-reported mild to moderate lower back pain were recruited for this study. Each subject gave informed written consent to participate in accordance with the University of Calgary's Conjoint Health Research Ethics Board policy on research using human subjects. The subjects were randomly allocated to either the intervention group or control group (Table 1). Sample size was based on the ability to demonstrate with 80% power a difference between groups of 20/100 on the visual analog scale (VAS) for pain after golfing where the expected minimum change between baseline and 6 weeks was 20 mm and the standard deviation of change was 20 mm, with alpha set at $P = 0.05$.

Intervention

An unstable shoe, the MBT sandal (Figure 1), was distributed to the intervention (MBT) group after completion of a blind baseline assessment. For the 6-week duration of the study, all subjects were asked to golf a minimum of 1 round of golf (18 holes) each week and to practice hitting balls at a driving range for a minimum of 90 minutes each week. In addition to this, subjects in the intervention group were asked to wear the unstable shoes for as long as possible each day. Rounds of golf were played in regular golf shoes for both groups. However, the intervention group completed the practice sessions in the unstable shoes. No remuneration was provided to the subjects for the required rounds of golf or time at the driving range. The subjects did, however, keep the unstable shoes at the end of the 6 weeks, and those in the control group were given a pair upon completion of the study.

Testing Protocol

All measurements were completed in the Human Performance Laboratory at the University of Calgary. The testing protocol consisted of a baseline assessment of golf performance using motion analysis of 20 swings (ten 6 iron and 10 driver), baseline balance scores using both static and dynamic balance tests, and a baseline score of perceived LBP recorded on a 100-mm VAS. After baseline measures, subjects were randomly allocated to either the intervention group or control group. A second set of 20 swings (ten 6 iron and 10 driver) was completed by all subjects after placement into groups. The intervention group wore the unstable sandals, and the control group repeated the 20 swings in their regular golf shoes. This allowed for the quantification of the effect that the unstable shoes initially had on golf performance (intervention group) and also the effect of repeating a session in regular shoes that would account for any learning or fatigue effect. Subjects returned to the Human Performance Laboratory after 6 weeks of participation to repeat the testing procedure.

Logbooks

Subjects were asked to complete a daily log, which was provided to them at their baseline testing session. Entries in the log were specified to (a) how many hours the subjects were active on their feet each day; (b) how many of those hours were in the unstable shoes (for the intervention group); (c) if they practiced hitting balls that day, and if so, for how long; and (d) if they had played a round of golf that day, and if they did, to record an LBP score on a 100-mm VAS in the logbook after the round of golf. Logbooks were returned to the examiners at the midpoint and at the end of the 6-week test period. The subjects' self-reported compliance to the protocol is presented in Table 3.

TABLE 1. Summary of Baseline Data for the Test (MBT) and the Control Groups

	MBT Group			Control Group		
	Result	CI Lower	CI Upper	Result	CI Lower	CI Upper
No. of subjects	17	—	—	19	—	—
Age, y	51.10	44.89	57.31	48.79	43.14	54.43
Height, m	1.81	1.79	1.83	1.81	1.79	1.83
Weight, kg	87.00	82.08	91.92	88.78	83.53	94.04
BMI, kg/m^2	26.52	25.04	28.00	26.94	25.49	28.40
VAS LBP recall in laboratory, /100	39.50	33.44	46.91	41.40	33.39	49.41
VAS LBP first recorded, /100	37.15	25.12	53.34	39.54	31.92	50.02
Static eyes closed balance right leg, s	20.22	9.00	31.43	17.26	9.19	25.33
Dynamic eyes open balance right leg, s	32.61	14.93	50.28	28.47	9.79	47.15
Static eyes closed balance left leg, s	18.92	5.15	32.70	15.60	9.32	21.89
Dynamic eyes open balance left leg, s	37.13	17.96	56.29	34.12	14.24	54.00
Golf handicap	9.30	7.28	11.32	11.42	9.73	13.11
Driver clubhead speed, mph	95.94	91.07	100.80	96.39	92.03	100.75
Driver ball speed, mph	134.97	127.37	142.57	132.21	125.12	139.30
Driver ball carry, yd	165.65	145.58	185.73	163.91	141.13	186.70
Driver in–out path variability	0.90	0.75	1.05	1.32	0.86	1.78
Driver impact location variability, high and low	8.76	6.92	10.59	9.42	7.22	11.62
Driver impact location variability, toe and heel	11.10	9.19	13.01	11.98	9.91	14.05
6 iron clubhead speed, mph	81.53	77.89	85.16	82.70	79.36	86.04
6 iron in–out path variability	0.99	0.81	1.17	1.21	0.95	1.47
6 iron impact location variability, high and low	7.21	6.30	8.12	8.63	6.98	10.29
6 iron impact location variability, toe and heel	9.17	7.88	10.46	10.49	6.21	14.77

BMI, body mass index; CI, confidence interval; LBP, low back pain; MBT, Masai Barefoot Technology; VAS, visual analog scale.

Motion Analysis

Motion analysis data of the participant's golf swing was collected using the Motion Analysis Technology by TaylorMade (MAT-T; Carlsbad, California) system. All participants used the same TaylorMade 6 iron and driver for baseline and follow-up testing sessions as specific clubs are required for the use of the motion analysis system. The average of all 10 shots was used for the analysis.

The MAT-T system in the Human Performance Laboratory of the University of Calgary is a 3-dimensional motion capture system comprising nine 180-Hz, high-speed, infrared cameras with onboard processing and pattern recognition capabilities. The cameras convert each frame to a grayscale 640 × 480 digital image, process the image, and transmit the data back to the workstation using 100BaseT TCP/IP Ethernet communications. From the time history of the position and orientation of the clubhead before impact, the clubhead speed, in–out path, and impact location on the face are calculated.

The MAT-T system tracked the movement of the golf club using 6 retroreflective markers rigidly fixed on the club:

TABLE 2. Baseline Performance Variables in Golf Shoes and MBT Sandals

	MBT Group				Control Group			
	Golf Shoes	SD	MBT Sandals	SD	Golf Shoes	SD	Golf Shoes Repeated	SD
No. of subjects	17	—	—	—	19	—	—	—
Driver clubhead speed, mph	95.94	9.46	95.27	9.00	96.39	9.04	95.67	8.67
Driver ball speed, mph	134.97	13.16	132.40	14.45	132.21	12.81	131.47	12.09
Driver ball carry, yd	165.65	34.76	164.65	29.41	163.91	41.14	157.52	36.65
Driver in–out path variability	0.90	0.28	0.74	0.92	1.32	0.95	1.20	0.37
Driver impact location variability, high and low	8.76	3.57	7.74	3.16	9.42	4.56	10.12	3.84
Driver impact location variability, toe and heel	11.10	3.72	9.34	4.07	11.98	4.30	11.28	3.56
6 iron clubhead speed, mph	81.53	7.07	80.86	7.54	82.70	6.93	82.32	6.53
6 iron in–out path variability	0.99	0.35	0.76	1.10	1.21	0.54	1.09	0.42
6 iron impact location variability, high and low	7.21	1.77	6.54	1.55	8.63	3.44	8.11	2.87
6 iron impact location variability, toe and heel	9.17	2.51	9.90	2.42	10.49	2.04	10.00	2.84

MBT, Masai Barefoot Technology.

3 markers on the club grip and 3 on the clubhead that define its position in 3-dimensional space.

Ball speed was recorded using a proprietary TaylorMade launch monitor. It is an optical launch monitor, similar to commercially available optical launch monitors, such as the Vector Launch Monitor by Accusport (Winston-Salem, North Carolina). The launch monitor is triggered by the sound of impact to take an image with 2 flashes, thereby creating 2 images of the ball shortly after impact. From these 2 images of the ball, the ball speed, launch angle, and backspin are calculated.

Power and accuracy measures were selected to quantify golf performance. The power variables consisted of clubhead speed, ball speed, and ball carry (distance). Accuracy variables consisted of club path variation and impact location variability on the clubface (both high–low and toe–heel locations). Each variable was measured on a swing using a driver and 6 iron, except for ball speed and ball carry that were only measured with the driver club.

Clinical Measurements

At the initial assessment, the examiner measured each participant's height in meters and mass in kilograms. Body mass index was calculated with mass (kilograms) and height (meters) measurements using the formula: body mass index = mass/height^2. Each subject completed (a) a timed eyes closed static unipedal balance test on the laboratory floor and (b) a timed dynamic eyes open unipedal balance test protocol on an Airex Balance Pad (Alcan Airex AG; Sin, Switzerland) for both legs. For the static test, subjects balanced barefoot for as long as possible on 1 leg with their eyes closed. The dynamic test followed the same procedure; however, the subjects' eyes remained open, and the surface used was a high-density (50 kg/m^3) foam Pad (L-group, St Louis, Missouri). The loss of balance criteria included (a) removal of one hand from the hip, (b) touching the test surface with the non–weight-bearing foot, (c) movement of the weight-bearing foot from its original position, or (d) movement of the balance pad from its original position.[16] The static test was also stopped if the subjects opened their eyes. The clinical balance outcome measurements of interest were based on the maximum time (seconds), unipedal balance was maintained on each leg tested for each of the static and dynamic balance tests.

Visual Analog Scale

The subjects were asked to complete a VAS during their initial visit to the laboratory as a baseline indication of their perceived LBP following the last time they played 18 holes of golf. Additionally, they were asked to document the same visual analog test in the logbooks after every time they played a round of golf. The visual analog–scaled format has been shown to be reliable for indication of LBP (interobserver reproducibility, $r = 0.92$).[20] The VASs for the rating of perceived lower back pain after golfing was based on a 100-mm analog line format.[20]

Statistics

Data were analyzed using statistical software package (SPSS 16.0 for Windows, Release 16.0.1, SPSS, Chicago, Illinois). Change in LBP from baseline to week 6 was determined by using an independent samples *t* test. An average was taken of the daily logbook VAS scores for LBP for each week, which provided 6 average pain measurements for each subject corresponding to the 6 weeks of the study. The difference between the first and last week's LBP scores from the logbooks and the reported LBP at baseline and 6 weeks in the laboratory were calculated for the intervention and control groups. The mean change in the intervention group was compared with the mean change in the control group to determine the effect of the unstable sandals on LBP. Groups were assessed for equal variance using the Levene test for equality of variance. Independent samples *t* tests were also performed on the change in balance scores and the change in performance variables from baseline to follow-up. A secondary analysis of golf performance was completed to determine (a) the initial effect of the unstable footwear on the intervention group, and (b) the effect of fatigue between the first and second set of swings in the control group. These comparisons were made using paired *t* tests.

RESULTS

Three subjects dropped out of this study (all in the intervention group) before completion. The subjects who dropped out of the study did not differ (fell within the 95% confidence interval) from the remaining participants on any of the 15 primary baseline measurements (Table 1). Groups were considered to be normally distributed. Compliance to logbook return was 33 of 40 books distributed (Table 3). Subjects in the intervention and control groups practiced and played on average the same number of rounds of golf each week, were on their feet for similar hours each day, and began the study with approximately the same amount of lower back pain. Results for LBP, balance, and performance are recorded in Table 3.

TABLE 3. Summary of Logbook Information of the Test (MBT) and Control Groups

	MBT Group			Control Group		
	Result	CI Lower	CI Upper	Result	CI Lower	CI Upper
Time on feet per day, h	7.00	5.54	8.45	6.42	5.33	7.51
Time in sandals per day, h	3.07	2.27	3.87	—	—	—
Time at the driving range per week, min	131.85	86.38	177.31	126.26	104.25	148.28
Rounds of golf (18 holes) per week	2.89	2.33	3.45	3.04	2.68	3.40

CI, confidence interval; MBT, Masai Barefoot Technology.

The reliability of the performance variables was calculated from the baseline data and is presented in Table 5.

Low Back Pain

There was a significant difference ($t = -2.337$, $P = 0.03$) in perceived LBP when comparing the change from the first week with the last week of recorded pain measures immediately after golf as indicated in the subject's logbooks (Figure 2). There was also a significant difference in the change of perceived LBP between the intervention and control groups from baseline to week 6 as determined by the laboratory recall of LBP ($t = -2.020$, $P = 0.05$) (Figure 3).

Static and Dynamic Balance

There was no significant change between the intervention and control groups in static or dynamic balance scores on the right and left legs after 6 weeks.

Golf Performance

There was no difference between the change in performance of the intervention group compared with the change in performance of the control group in any of the performance variables after 6 weeks (Table 4). There was also no significant initial effect of the unstable sandals on golf performance at baseline in the intervention group compared with their performance in regular golf shoes (Table 2). There was no significant change in performance of the control group due to fatigue in the first testing session when comparing the first set of 20 swings with the second (Table 2).

DISCUSSION

Low Back Pain

Two separate reports of LBP were recorded for this experiment, and both resulted in significant reductions of perceived LBP in the intervention group. The measure of LBP filled out immediately after every round of 18 holes of golf in a logbook resulted in a greater magnitude of change in LBP compared with the laboratory assessments despite a reduction in sample size. It is thought that the logbook entries are a more accurate assessment of LBP after golf, as it was recorded immediately after the rounds of golf.

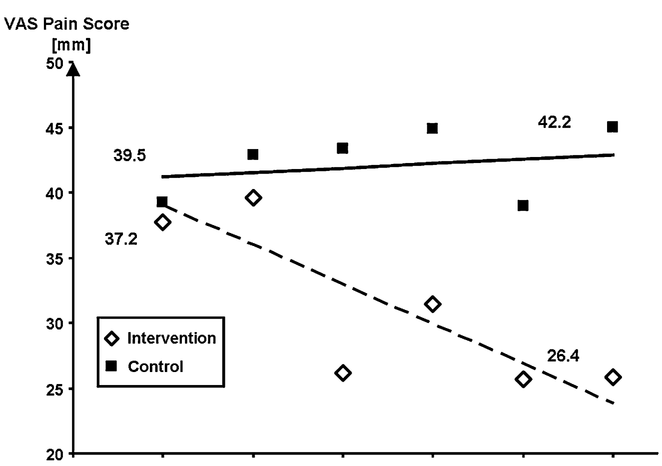

FIGURE 2. Average logbook pain score for the intervention and control groups immediately after playing 1 round of golf at weeks 1 and 6.

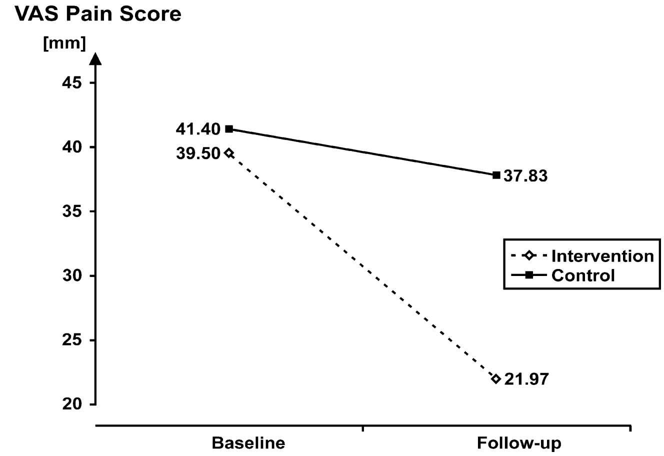

FIGURE 3. Average pain score as recalled at baseline and follow-up during in-lab measurements.

Due to the design of this experiment, some of the reduction in back pain could be attributed to a placebo effect of receiving the unstable shoes. With the available information on the possible advantages of the unstable shoes through the Internet, retail stores, and word of mouth, the intervention group could have been aware of the proposed advantages, and therefore the scores could have been reflective of what they thought should happen as opposed to the actual perceived LBP.

Balance

The unstable shoe condition has previously been shown to improve the balancing ability of subjects training in the shoe during daily activities.[16] The 6-week training used in this study did not show the same effect as there were no significant differences in balance. Although not significant, the largest between-group differences in balance times from baseline to follow-up were the dynamic balance score on the left leg. During the downswing, the golfers transfer their weight toward the target side of the body and finish the swing with almost all their weight balanced on the front (left) foot. The repetitive balancing on the left leg as a result of hitting balls at the driving range may possibly account for this difference in balance times only on the left leg for the (right handed) intervention group.

The inconsistency in balance results of this study as compared with the previous investigation[16] could be due to the superior baseline balance abilities of the golfers. The balance scores of the golfers were approximately 5 times longer for eyes closed balance and almost twice as long for eyes open balance when compared with the knee osteoarthritis population. In addition, the knee osteoarthritis study duration was 12 weeks compared with the 6-week duration of this study. There is a potential that the balance of the golfers would have continued to improve if the intervention period was longer.

TABLE 4. Summary of Mean Changes for the 6-Week Period of Measurement

	MBT Group					Control Group				
	n	Baseline	Follow-up	CI Lower	CI Upper	n	Baseline	Follow-up	CI Lower	CI Upper
VAS score baseline to 6 wk										
Value recorded in logbook, /100	14	37.15	26.41	−19.69	−1.80	19	39.54	42.15	−5.45	10.68
Value recorded in laboratory, /100	17	39.50	21.97	−27.78	−7.28	20	41.40	37.83	−13.79	6.64
Balance scores baseline to 6 wks										
Static eyes closed balance right leg, s	16	22.84	22.37	−9.89	8.83	19	17.26	26.14	−6.41	26.04
Static eyes closed balance left leg, s	16	21.08	28.46	−2.75	17.51	19	15.60	17.33	−6.47	10.22
Dynamic eyes open balance right leg, s	16	34.75	48.01	0.21	26.30	19	28.47	46.94	2.27	36.36
Dynamic eyes open balance left leg, s	16	41.80	58.17	−2.62	35.37	19	34.12	34.99	−12.09	13.84
Performance scores baseline to 6 wks										
Driver clubhead speed, mph	17	95.94	95.28	−2.07	0.75	19	96.39	95.67	−1.97	0.53
Driver ball speed, mph	14	134.97	132.65	−4.80	0.16	15	132.21	131.17	−3.34	1.26
Driver ball carry, yd	14	165.65	168.81	−11.37	17.67	15	163.91	160.85	−18.70	12.56
Driver in–out path variability	17	0.90	1.17	0.11	0.43	19	1.32	1.35	−0.32	0.38
Driver impact location variability, high and low	17	8.76	9.89	−1.04	3.31	19	9.42	9.99	−1.68	2.81
Driver impact location variability, toe and heel	17	11.10	11.28	−2.19	2.55	19	11.98	12.60	−1.54	2.77
6 iron clubhead speed, mph	17	81.53	80.06	−3.13	0.20	19	82.70	81.47	−2.17	−0.29
6 iron in–out path variability	17	0.99	1.09	−0.13	0.32	19	1.21	1.33	−0.32	0.56
6 iron impact location variability, high and low	17	7.21	8.28	−0.27	2.39	19	8.63	7.79	−2.40	0.71
6 iron impact location variability, toe and heel	17	9.17	8.47	−2.4	1.02	19	10.49	9.91	−5.08	3.92

95% CI is for the change score from baseline to follow-up.
CI, confidence interval; MBT, Masai Barefoot Technology; VAS, visual analog scale.

The initial proposed mechanism for this decrease in LBP was through an increase in the stability of the golfers. Although the balance did not substantially change, a decrease in LBP was still achieved. The unstable shoe could have resulted in an increased engagement of core muscle groups and an increased postural muscle activity. This would allow for a decrease in LBP without directly influencing standing balance results. A future study of the activation of the core muscles while wearing the unstable shoes could confirm this hypothesis.

Performance

It has been claimed that balance and stability are essential components for a successful and consistent golf swing.[17,21,22] Based on this, it was speculated that the initial impact of introducing an unstable shoe to a golf swing would have a negative effect on golf performance. However, a reduction of performance between the stable and unstable shoe conditions was not seen at baseline (Table 2) for power (clubhead speed, ball speed, and ball carry) or consistency (path and impact variability) variables. During the game of golf, players are required to perform swings on a variety of playing surfaces including sloped terrain, long grass, and sand. Compensatory mechanisms used to perform shots in these game situations may also be triggered while wearing unstable shoes, creating a consistent performance in both footwear conditions. Furthermore, there was no difference in the change in golf hitting performance due to playing golf for 6 weeks between the control group and for the unstable shoe group (Table 4). This result shows that the golf-related mechanics do not change when using an unstable shoe condition (handicap < 15). An interesting additional result was that not only the performance variables but also their standard deviations were not influenced by the unstable shoe condition. Thus, when using the unstable MBT shoe, the golfers were as consistent in their swing as with normal golf shoes.

TABLE 5. Reliability Scores for the Performance Variables Calculated from the Baseline Swing Data

Variable	ICC
Driver clubhead speed	0.982
Driver ball speed	0.987
Driver ball carry	0.952
Driver in–out path	0.993
Driver impact location, high and low	0.821
Driver impact location, toe and heel	0.818
6 iron clubhead speed	0.994
6 iron in–out path	0.997
6 iron impact location, high and low	0.792
6 iron impact location, toe and heel	0.859

ICC, intraclass correlation coefficient.

The results of this study suggest that the unstable shoe has the potential to reduce perceived LBP in golfers. The reduction of LBP is expected to start relatively soon after starting to use the shoes. They may even be more pronounced if the unstable shoes would be used during the actual golf games. Adding an element of instability did not negatively affect golf performance. However, the potentially positive effects of an unstable shoe as a training device need further study.

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