

ORTHOSES IN GOLF

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Abstract

The following experiment is undertaken to highlight the benefits Superfeet trim-to-fit foot orthoses provide in golf shoes. This investigation evaluated the effects of foot orthoses on both comfort and performance in golf and the differences between Superfeet Orange and Superfeet Carbon trim-to-fit foot orthoses.

26 volunteers from Caversham Heath Golf Club with a range of handicaps took part in the study.

A golf simulator was used to record performance related outputs, such as Club Head Velocity, Ball Speed, Ball Carry, and Total Distance, for each participant before and after the use of a Superfeet foot orthoses over a period of 3-5 rounds of golf.

The intervention of a Superfeet foot orthoses, over a period of 3-5 rounds, was found to increase Club Head Velocity, Ball Speed, Ball Carry, Total Distance, and Offline Accuracy by an average of 3mph, 6mph, 11 yards, 12 yards, and 4 yards respectively. With Superfeet Carbon yielding an average increase of 4mph, 6mph, 12 yards, 13 yards, and 4 yards; as opposed to Superfeet Orange yielding an average increase of 3mph, 5mph, 10 yards, 11 yards, and 4 yards.

Ball Spin (side and back spin) was also found to reduce after the intervention of orthoses.

Participants' comfort over a round of golf was attained through a questionnaire and interview before and after the intervention of the Superfeet foot orthoses.

All participants' comfort was reported to increase, with fatigue and muscle pains in the lower extremities and back reduced.

Participants' scores were taken from 3-5 rounds of golf before the use of orthoses and compared against their scores after the intervention of foot orthoses. Over this period of time there was found to be an average improvement of 1 shot over 3-5 rounds of golf, participants also reported increases in performance during later holes as they maintained more energy and less muscle pains.

The study has concluded that the intervention of a Superfeet trim-to-fit foot orthoses over a period of 3-5 rounds of golf, improves comfort in golf shoes; and influences an increase in Club Head Velocity of 3mph relating to an increase in Ball Carry of 11 yards, and can improve offline accuracy over a distance of 100-310 yards by 4 yards.

Introduction

It is known that a correctly fitted foot orthoses stabilises the foot by aligning the bones in the foot and ankle in a stable neutral position.

By allowing the orthoses to stabilise the foot, the muscles in the lower extremities are no longer forced to over work in order to stabilise the foot. Overworking of the muscles can lead to an increase in muscle fatigue, in turn increasing the chance of injury. Therefore by allowing the orthoses to stabilise the foot, muscle fatigue is reduced, in turn reducing the chance of injury and theoretically allowing performance over a long round of golf to increase as the muscles maintain more energy.

Foot orthoses are used everyday to help prevent and recover from a number of injuries. To name a few, they are used in the recovery and prevention of Plantar fasciitis, Achilles tendinitis, Shin splints, and Patellofemoral pain syndrome (runner's knee), and numerous other lower limb musculoskeletal injuries.

Superfeet have been engineering orthoses since 1977, both custom fitted orthoses and over the counter trim-to-fit orthoses. They currently have a range of more than 17 over the counter orthoses and 7 custom fitted orthoses designed to be used in all types of shoes. They are designed for every sporting activity, with each insole engineered differently to give specific performance characteristics for each activity.

The Superfeet Orange product has been engineered with greater torsional stiffness than some of the other orthoses in the range, theoretically this should allow for better support and stability throughout the golf swing, more importantly the downswing. It also has a soft cushioned top sheet to allow for greater shock absorption and provide comfort throughout the round

of golf. However the new Superfeet Carbon product, engineered with a carbon reinforced stabilizer cap with a durable, ultra-light foam layer, gives the orthoses a higher torsional and compressive strength due to its carbon fibre construction.

This study hopes to investigate the benefits of an orthoses with good torsional strength and good shock absorption characteristics, versus a lighter orthoses with greater torsional strength but less shock absorption.

In a small study of 12 experienced golfers by Stude DE & Brink DK on the 'Effects of nine holes of simulated golf and orthotic intervention on balance and proprioception in experienced golfers' [1], it was found that for experienced golfers, the use of a custom fitted foot orthoses over a 6 week period reduced the effects of fatigue associated with 9 holes of simulated golf, this therefore allows for increased performance over the 9 holes of golf. Measurements of club head velocity were also taken in the study and an increase of 3.5mph was found through the use of the custom orthoses, this translates approximately to a 15-yard increase in ball carry. This study aims to test the effects of orthoses on a broader range of factors from performance in a golf simulator to performance on the golf course, and comfort over the time spent in the golf shoes.

The following experiment is undertaken to highlight the benefits Superfeet trim-to-fit foot orthoses provide in golf shoes. Although the orthoses are not custom fitted to each subjects' foot, they still provide far greater support than a golf shoe's standard insole, the advantage of a custom fitted insole over the trim-to-fit insole is that it will be an exact mould of the individual's foot whereas the trim-to-fit has been shaped to an average of over 300 people to give the optimum support for as wide a range of people as possible.

The study's three main aims are as follows: to determine improvements made to the comfort of individuals over a round of golf; to determine improvements made in golf swing characteristics through the use of a Superfeet foot orthoses in a golf simulator; and to determine differences between Superfeet Orange and Carbon.

The study has been designed to determine improvements in various outcomes of a golfer's swing after the use of a Superfeet trim-to-fit orthoses over a period of 3-5 rounds of golf. A golf simulator will be used to take measurements such as ball carry, club head velocity, offline accuracy, sidespin, and backspin; these results will be assessed before and after the intervention of orthoses in order to highlight improvements made. Attempts to determine the differences between Superfeet Orange and Carbon will also be made from the golf simulator data.

The study also aims to find out whether comfort and performance during 18 holes of golf is improved through the use of Superfeet trim-to-fit foot orthoses.

It is known that foot orthoses can help to stabilise the bones in the foot and ankle by bringing the ground up to meet the foot in its most stable position. By studying weight transfer and foot position through the stages of a golf swing it can be seen theoretically how beneficial a foot orthoses can be to a golfer's swing.

During swing set up, weight is evenly distributed on both feet with slightly more weight on the forefoot as you lean over, and slightly more weight on the insides of both feet. During the backswing your weight shifts to the back foot and is evenly distributed on the back foot or maintained slightly on the inside of the back foot. If weight shifts to the outside of the back foot it causes the golfer to sway during the swing resulting in bad contact with the ball. If the foot is not stabilised it causes

the muscles of the lower extremities to work overtime in order to stabilise the foot and maintain the correct weight distribution, this can lead to fatigue in the muscles and therefore injury.

By breaking down the stages of the swing above, it can be seen how stabilising the foot to allow a more controlled and efficient weight transfer leads to a better contact with the ball and a more efficient power transfer. Therefore it can be theorised that the use of foot orthoses will improve various outcomes of a golf swing by creating a more stable stance and efficient swing. It also shows how the foot orthoses helps to reduce fatigue in the muscles as they are not over worked to stabilise the foot and ankle, this leads to an improved comfort during 18 holes of golf as the muscles of the lower extremities are not fatigued as quickly; again leading to a reduced chance of injury. The performance over 18 holes also increases as the muscles maintain more energy further into the round producing more stable and efficient swings.

Methodology

The experiment was created in order to determine whether the use of Superfeet trim-to-fit foot orthoses used in golf shoes improves comfort and performance, as well as highlighting the differences between Superfeet Orange and Superfeet Carbon.

26 golfers with a range of handicaps, who haven't previously used foot orthoses in their golf shoes, volunteered as subjects for the study. The subjects were randomly assigned to one of 2 groups: Group Orange or Group Carbon. Subjects from Group Orange would be fitted with 'Superfeet trim-to-fit Orange' orthoses to use in their golf shoes (in place of the original shoe insoles). Subjects from Group Carbon would be fitted with 'Superfeet trim-to-fit Carbon' orthoses to use in their golf shoes (in place of the original shoe insoles). Subjects attended two golf simulator sessions separated by a month period in which the subjects completed 3-5 rounds of golf. During the golf simulator sessions various shot characteristics were recorded including club head velocity, ball speed, backspin, sidespin, ball carry, total distance and offline accuracy.

Prior to the study, volunteers complained of various injuries and pains that were exasperated when playing golf. Brief interviews with each volunteer and the comfort questionnaires completed by the volunteers highlighted these injuries and then allowed for a comparison to be done after the use of the orthoses to show if and how they had helped to reduce these pains. The extent of each injury was assessed with a simple pain rating, an explanation of how and when it occurs during their golf, and how it affects their enjoyment of the game; this was done using a comfort questionnaire (sheet 2 in Appendix) and a brief interview before each simulator session.

When the subjects arrived they were taken through the test procedures and asked to sign a consent form (sheet 1 in Appendix). The subjects handed in their completed comfort questionnaires (sheet 2 in Appendix) and had a brief conversation regarding the comfort questionnaire. The Subjects also handed in their scores from 5 previous rounds of golf.

The first golf simulator session was then started; the subjects took 3 warm up shots before 10 recorded shots whilst using their golf shoes with the standard insoles. They were allowed to use either a Driver or 5 Iron. Subjects were then fitted with the Superfeet orthoses from their respective group. The orthoses was checked against their foot to ensure the correct size had been selected, and then trimmed to fit into their shoe.

Once the first session was completed, subjects were thanked for their participation and given instructions on how to proceed. They were asked to complete 3-5 more rounds of golf whilst using the orthoses; they were also asked to complete a comfort questionnaire again after each round.

After they had completed the above instructions over a month period, subjects returned for a final golf simulator session in which subjects again took 3 warm up shots followed by 10 recorded shots however this time they used their respective Superfeet orthoses. Once the final session was completed, subjects were thanked for their participation and allowed to keep their Superfeet orthoses, they were also given a spreadsheet with their results from both golf simulator sessions as they had not seen their results during the study.

The shot outcomes calculated by the golf simulator were used to compare the results between the use of the Superfeet Orange, Superfeet Carbon, and no orthoses at all. This data, including the comfort questionnaires and interviews,

is then collated and used to highlight improvements made in comfort, scores during a round of golf, shot outcomes and shot perception from the golf simulator. Data would also be compared between the groups to highlight differences between the two orthoses used, the club used, and the subjects' handicaps.

Results Performance

Change Due to Orthotic Intervention	Shot Perception	Club Head Velocity (mph)	Ball Speed (mph)	Launch Angle (°)	Azimuth (°)	Side Spin (rpm)	Back Spin (rpm)	Total Spin (rpm)	Peak Height (yds)	Descent Angle (°)	Ball Carry (yds)	Total Distance (yds)	Offline Accuracy (yds)
Average	1	3	6	-1	0	-97	-114	-150	1	0	11	12	-4
Orange Average	1	3	5	-1	1	-41	-167	-187	0	-1	10	11	-4
Carbon Average	1	4	6	0	-1	-152	-62	-113	2	1	12	13	-4
Handicap <10	1	4	4	0	1	7	-25	-29	2	1	10	9	-5
Handicap 10-20	1	3	7	-1	-1	-220	-172	-249	0	-1	12	14	-4
Handicap >20	2	4	5	0	1	4	-148	-142	0	-1	11	14	-1

Table 1. Average change after intervention of orthoses over a period of 3-5 rounds of golf.

Table 1 shows the average change after orthoses intervention over a period of 3-5 rounds of golf, shot characteristics from both simulator sessions (pre and post orthoses intervention) have been compared above, subtracting the averages of all golfers pre orthoses intervention from the averages of all golfers post orthoses intervention.

Positive averages in Shot Perception, Club Head Velocity (CHV), Ball Speed, Ball Carry, and Total Distance relate to increases after orthoses intervention. Negative averages in Offline Accuracy are improvements after orthoses intervention, as they represent the ball path being straighter.

Negative averages in Spin are reductions in spin after orthoses intervention.

Change Due to Orthotic Intervention	Shot Perception	Club Head Velocity (mph)	Ball Speed (mph)	Launch Angle (°)	Azimuth (°)	Side Spin (rpm)	Back Spin (rpm)	Total Spin (rpm)	Peak Height (yds)	Descent Angle (°)	Ball Carry (yds)	Total Distance (yds)	Offline Accuracy (yds)
Average	0	-1	-2	-1	-1	-72	-143	-141	-1	-1	-5	-4	-1
Orange Average	0	-2	-2	-1	-1	-54	-145	-147	0	-1	-3	-4	-1
Carbon Average	0	-1	-2	-1	-1	-90	-141	-136	-2	-2	-7	-4	-1
Handicap <10	0	-1	-2	-1	0	-46	-162	-176	-2	-2	-7	-4	-4
Handicap 10-20	0	-1	-1	0	-1	-115	-185	-188	0	0	-2	-3	0
Handicap >20	0	-2	-4	-2	-2	-18	0	44	-2	-2	-9	-7	3

Table 2. Average change in standard deviation after intervention of orthoses over a period of 3-5 rounds.

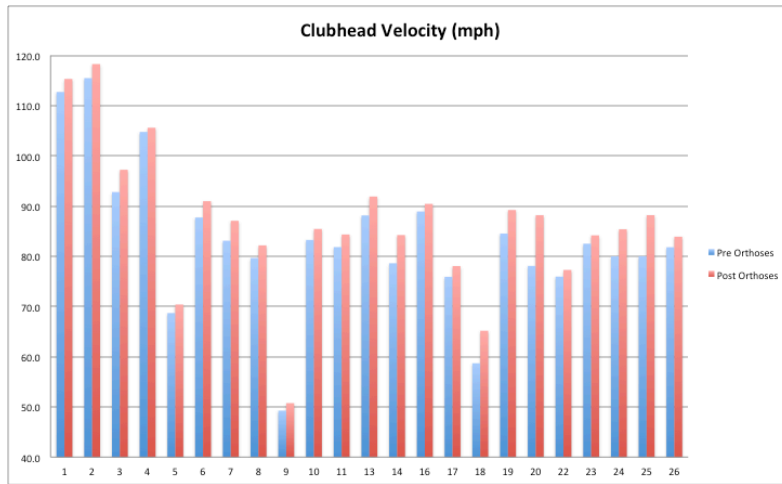
Table 2 shows the average changes in standard deviation due to orthoses intervention. All negative values indicate a reduction in standard deviation, this relates to a closer spread of results. It highlights a more consistent shot after the intervention of orthoses.

Change Due to Orthotic Intervention	Shot Perception	Club Head Velocity (mph)	Ball Speed (mph)	Launch Angle (°)	Azimuth (°)	Side Spin (rpm)	Back Spin (rpm)	Total Spin (rpm)	Peak Height (yds)	Descent Angle (°)	Ball Carry (yds)	Total Distance (yds)	Offline Accuracy (yds)
Driver	2	3	5	-1	0	-130	-275	-310	0	-1	11	13	-6
Orange	2	3	6	-2	1	-59	-237	-254	-1	-2	11	14	-5
Carbon	2	3	4	1	-1	-254	-382	-452	2	0	12	15	-9
5 Iron	1	4	6	-1	0	-44	106	74	2	1	10	9	-1
Orange	1	3	5	0	0	-11	-43	-70	2	2	9	7	-3
Carbon	1	5	8	-1	-1	-67	205	170	2	1	11	10	0

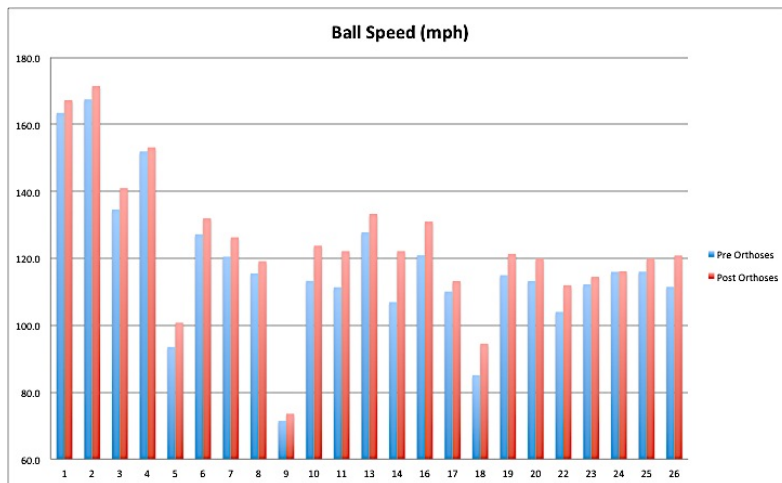
Table 3. Shows differences after intervention of orthoses vs. club used.

Table 3 shows the average change after orthoses intervention over a period of 3-5 rounds of golf, it also shows the changes in relation to the use of either a Driver or 5 Iron.

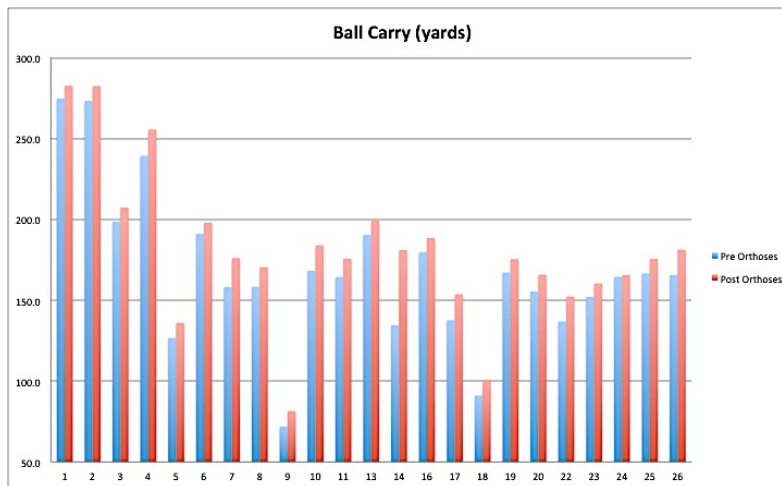
Graph 1
Clubhead Velocity (mph)



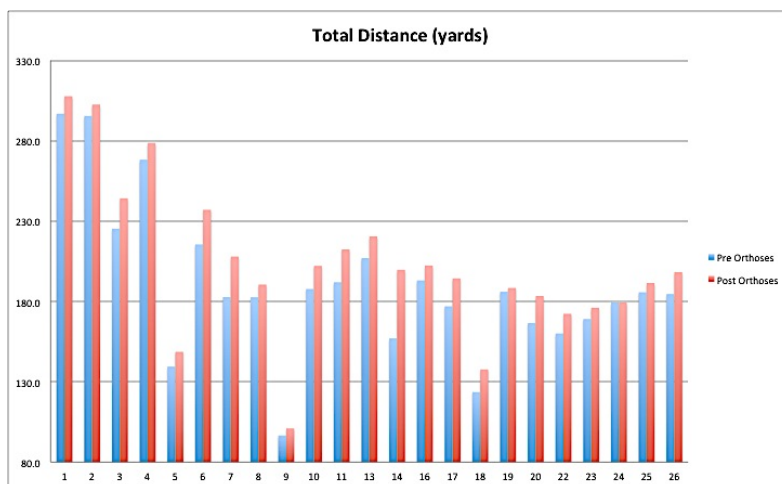
Graph 2
Ball Speed (mph)



Graph 3
Ball Carry (yards)



Graph 4
Total Distance (yards)



Graphs 1-4 clearly show all subjects' CHV, Ball Speed, Ball Carry, and Total Distance increased after the intervention of orthoses.

Subject 12, 14, 15, and 21 were removed from the study due to reasons highlighted in the discussion, although Subject 14 is shown in the graphs.



Graph 5
Shot Perception

Graph 5 shows subjects' shot perceptions before and after the intervention of orthoses, 23 out of 24 subjects' perception of how they felt each shot in the simulator went increased by a rating of 1 or more (out of 10). One subject's perception can be seen to decrease by a rating of 1.

Through comparison of scores from 3-5 rounds of golf before and after the intervention of orthoses, 15 out of 23 subjects' average round scores improved, 3 out of 23 subjects' average scores decreased, and 5 out of 26 subjects' average scores stayed the same. The red highlighted scores are the subjects that removed themselves from the study, as mentioned in the discussion, their scores have been ignored when calculating the average shown as a 1 shot increase in table 4.

Improvement in Round Score
1
1
0
2
3
2
0
3
1
-1
-1
-3
0
0
3
2
0
4
1
2
2
1
1
1

Table 4

Results Comfort

Participants were given a comfort questionnaire to answer after each round of golf played before and after the intervention of foot orthoses (sheet 2 in Appendix).

They were quizzed on this in a brief interview before each simulator session in order to get a more in depth explanation of any problems they may have or have not mentioned on their comfort questionnaire.

A final debrief questionnaire (sheet 3 in Appendix) was also completed by each volunteer at the end of the study that highlighted their perception of the foot orthoses they had been using.

Participants' problems highlighted from the first comfort questionnaire included pains and aches in:

- Neck
- Bicep
- Wrist
- Lower back
- Hip
- Thigh
- Calf
- Shin
- Ankle
- Heel
- Arches
- Ball of foot

These problems were given a pain rating out of 10 (0 being no pain, 10 being excruciating pain). This rating, along with notes taken from the interviews with each subject, was compared to the questionnaire and interview after the intervention of orthoses at the second simulator session.

Every participant reported an instant improvement in comfort when they first put their golf shoes on with the orthoses in. Reporting that they instantly felt more supported in their shoes and felt more stable in their golf stance.

Clear improvements in comfort and pain relief were found in the second

simulator session for all subjects. 3 subjects reported slight discomfort at the end of their first round which is expected with any foot orthoses when first wearing them as they can take some time to break in and should not be worn for more than 4 hours on the first day of use. As soon as the break in period was over all subjects reported a noticeable improvement in comfort and reduction in fatigue at the end of the round and the following day.

After the use of orthoses over a period of 3-5 rounds of golf, all muscle pains in the lower extremities highlighted before the introduction of orthoses, were found to either reduce in pain rating or disappear in all subjects that had reported them. Pains that were reduced after the introduction of the foot orthoses were:

- Lower Back
- Hip
- Thigh
- Calf
- Shin
- Ankle
- Heel
- Arches
- Ball of foot

Muscle pains and aches that weren't relieved in any way were:

- Neck
- Bicep
- Wrist

Noticeably these are upper extremity problems and are unlikely to have been aided through the use of orthoses.

A reduction in fatigue for all subjects at the end of each round was also reported in the comfort and debrief questionnaires, with subjects noticing that they were not as tired or stiff the following morning. 20 out of 22 subjects reported that their fatigue after a round of golf was reduced after the intervention of the orthoses.

Conclusion

The results from the golf simulator sessions show that there is an average increase of 3mph in club head velocity after the intervention of Superfeet trim-to-fit orthoses over a period of 3-5 rounds of golf. They also show that this increase in club head velocity results in an increase in ball carry of 11 yards. This can clearly be seen in Table 1 and Graphs 1-4.

From Table 1 it can be seen that there is an average increase in Ball Carry of 11 yards, Total Distance of 12 yards, and an increase in offline accuracy of 4 yards. Table 1 also shows a reduction in the amount of sidespin and backspin placed on the ball at impact; subject feedback suggests that this is most likely due to a more stable downswing and thus a better club head to ball impact, however further study into this would need to be done in order to confirm this.

Subjects' average shot perception is shown to increase by a rating of 1 when using the orthoses, this again suggests that the subject is more stable in their swing as they were asked to base their rating on the feel of the swing rather than the simulator's output results for the shot.

The use of a Superfeet trim-to-fit orthoses has clearly been shown in this study to improve comfort in subjects' golf shoes, through providing a stable support for the foot, reducing fatigue, and reducing various muscle pains and aches in the lower extremities, hips and lower back.

In the matter of Superfeet Carbon vs. Superfeet Orange, Carbon was linked to an increase in club head velocity of 4mph and ball carry of 12 yards, whereas Orange was linked to an increase of 3mph and 11 yards. This difference between the two orthoses is not considered significant

enough to confidently state that Carbon is better than Orange, this is also discussed below in the discussion.

Table 3 shows that after the intervention of an orthoses there is a greater increase in ball carry and offline accuracy when using a driver as opposed to a 5 iron, however there is a greater increase in club head velocity when using a 5 iron as opposed to a driver.

It also highlights an advantage in the use of a Superfeet Carbon orthoses as opposed to an Orange when using a 5 iron, in both club head velocity and ball carry; however there is not significant advantage of one over the other when using a driver.

With reference to handicaps, Table 1 shows that subjects achieved the greatest increase in club head velocity with a handicap below 10 and above 20, and subjects achieved the greatest ball carry increase with a handicap between 10 and 20. It also shows that the better the handicap, the greater the increase in offline accuracy with subjects under 10 improving accuracy by 5 yards, 10-20 improving by 4 yards, and over 20 improving by just 1 yard.

The standard deviation table (Table 2) shows that after the intervention of orthoses, shots in the simulator were more consistent. This could possibly be due to the increased stability subjects highlighted in their questionnaires and interviews.

Table 4 highlights the improvements made in round scores after the intervention of orthoses. It highlights an average improvement of 1 shot over the 23 subjects that completed the study. 15 subjects average scores improved over 3-5 rounds of golf by between 1-4 shots; 3 subjects' average scores decreased by between 1-3 shots; and 5 subjects average scores remained the same.

Discussion

Subjects

26 subjects started the study and completed the first simulator session, 23 finished the full study completing the second simulator session. The 3 subjects that pulled out of the trial removed themselves for different reasons.

The first subject pulled out as they had injured their hand and so was unable to complete the second simulator session and required rounds of golf after the first session.

The second subject pulled out as they had aggravated an existing back condition (not whilst playing golf) meaning that they were unable to complete the second simulator session and the 3-5 rounds of golf.

The third subject pulled out of the study due to worries about pains in their Achilles tendon. Although they had Achilles problems before entering the study, they experienced a slight discomfort during the first use of the orthoses and became worried that the orthoses would aggravate their existing Achilles problem; due to this they took the orthoses out removing themselves from the trial. An interview was done with the subject after pulling out of the trial, in which it was discovered that the discomfort was due to the subject getting used to the feeling of the orthoses providing support for their foot (brief wearing in period) and although they didn't experience any pain was worried and took the orthoses out. Following the interview the subject decided to try the orthoses in a pair of trainers in order to wear them in, finding them beneficial, unfortunately by this point they had already withdrawn from the study.

Subject 14 has been ignored when calculating averages and standard deviation as they have been considered an anomaly. Although their shot characteristics improved, they

improved by an amount roughly four times the average. After investigation of this fact it was found that the subject had completed a number of lessons in which they had been taught to change their swing technique. It was assumed that this could have had a major effect on the results from the second simulator session. This meant that the lessons were more likely to be the overwhelming factor that influenced the improvements made rather than the orthoses. For this reason subject 14's results were labelled as anomalies in order to prevent them from affecting the final results, and were excluded when calculating the averages.

Subject Perception

In a debrief questionnaire and interview with each subject at the end of the study, 23 out of 23 of the subjects reported that the orthoses provided an increase in comfort over a round of golf; 23 out of 23 reported that they felt more stable in their stance; 21 out of 23 reported that they felt the orthoses had improved their performance over a round of golf; 21 out of 23 reported that the orthoses reduced their fatigue after a round of golf; 18 out of 23 reported that they felt the orthoses had improved their swing; and 23 out of 23 said that they would continue to wear the orthoses and would recommend them to others.

As mentioned above, all subjects in the study reported a significant increase in comfort, most notably saying that they felt more stable in their stance; and whilst wearing them during a round of golf, forgot the orthoses were even in their shoes.

It is clear that an improvement in subjects' comfort was found due to the use of orthoses. This was highlighted through the use of the comfort questionnaires and interviews.

However this increase in comfort was also noticed instantly in the first golf simulator session when subjects first put their shoes on with the orthoses in; subjects immediately commented on the noticeable improvement in comfort and

stability they felt in their shoes. Some mentioned that they felt strange as they took their first steps but got used to them within a matter of 4 or 5 steps. The quotes section in the appendix lists various quotes given by subjects as they tried on the orthoses for the first time, and after they had used them for 3-5 rounds of golf.

Further Study

If further study was to be done or the study was to be repeated, there are some improvements to test procedures that could be implemented:

Prevent shot output from being shown on screen after the shot.

Remove shot line after each shot to prevent subjects comparing between shots depending on shot line.

Allow more time for each subject's golf simulator sessions so that they can take 20 shots rather than 10 to allow for a more reliable average to be taken; this extra time will allow for them to rest between shots so that fatigue does not become a noticeable variable in the simulator shot results.

Allow more than 3-5 rounds of golf to be undertaken between the golf simulator sessions to see if there is an increase in round scores.

View each subjects scores for each hole rather than the whole round to highlight any improvements in the later holes due to reduced fatigue.

Round scores improved after the intervention of orthoses for 14 subjects, the average increase for all 23 subjects was 1 shot. Over a 3-5 round period it is hard to say definitively whether this was influenced by the intervention of orthoses as there are many other factors to be considered such as conditions on the day, and how competitively the round was taken. If further study was to be done, it may be sensible to allow for more than 5 rounds to be played after the intervention of orthoses before the second simulator session in order to gain a more reliable average; and all

rounds played must be in the same competition format.

Although it can't be shown using the round scores, subjects mentioned in their post orthoses interview that they felt they did better in the rounds whilst using orthoses but there were other factors that they felt effected their round scores (such as bad day/weather). Again if further study was to be done then it would be sensible for subjects to play their rounds on the same course and to hand in scores for each hole to see if there is a greater performance over the back nine holes when fatigue would usually kick in.

This slight advantage of Carbon vs. Orange, highlighted in table 1, is not labelled as significant as subject 14 was using an Orange orthoses, and although his improvements were labelled anomalies due to undertaking lessons, if the improvements were in fact down to the orthoses, Orange would have the advantage over Carbon in ball carry and total distance as seen in table 5 (in the appendix).

The lack of a control group in this study was not due to design; due to budget and time constraints the study was unable to include a control group to compare against, as the golf club volunteers did not want to participate in the study unless they got to use the orthoses. Instead the subjects' results from the first simulator session were used as the control with the standard insoles to compare against. If further study was to be done, a control group would be created using two separate golf clubs, one using the orthoses and the other just getting to use the golf simulator for free; this way the control group golf club would not know about the orthoses used in the study, would create a control group.

This study has highlighted average improvements in club head velocity of 3mph, offline accuracy of 4 yards, ball carry of 11 yards, and reductions in ball spin, further studies into the reasons

why the orthoses cause these improvements could be done. Such as repeating a similar experiment using club head impact markers and high frame rate video recording equipment to determine whether a better club head on ball impact is achieved. 3D coordinate measuring equipment such as CODA or Vicon could be used to map the path of the club and position of the knees, hips, and feet during the swing. A previous study, mentioned in the introduction, into the effect of orthoses on 9 holes of simulated golf highlighted a significant influence on pelvic rotation; this could be a possible cause for the increase in club head velocity and therefore increase in ball carry.

References

[1]

http://redwoodcitybackpainrelief.com/Laptop_backup/Documents/Business%20Plan/Golf/Gait%20orthotics%20and%20golf.pdf

Effects of nine holes of simulated golf and orthotic intervention on balance and proprioception in experienced golfers. - Stude DE, Brink DK.

www.superfeet.com

Information on Superfeet orthoses product range.

<http://www.solutions4feet.com/>

Orthoses training provided by Solutions4feet.

<http://www.foresightsports.com/en/products/gc2-smart-camera-system>

Information on Golf Simulator GC2.

Equipment & Thanks

Orange and Carbon orthoses provided by Superfeet.

Training to fit orthoses given by Solutions4Feet.

Golf simulator GC2 and facilities provided by Caversham Heath Golf Club.

Appendix

Change Due to Orthotic Intervention	Shot Perception	Club Head Velocity (mph)	Ball Speed (mph)	Launch Angle (°)	Azimuth (°)	Side Spin (rpm)	Back Spin (rpm)	Total Spin (rpm)	Peak Height (yds)	Descent Angle (°)	Ball Carry (yds)	Total Distance (yds)	Offline Accuracy (yds)
Average	1	4	6	0	0	-147	-152	-207	1	0	12	13	-5
Orange Average	1	3	6	-1	0	-143	-234	-294	1	0	13	14	-6
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Handicap <10	1	4	4	0	1	7	-25	-29	2	1	10	9	-5
Handicap 10-20	1	3	8	-1	-1	-315	-246	-361	1	0	15	17	-6
Handicap >20	2	4	5	0	1	4	-148	-142	0	-1	11	14	-1

Table 5 – Average difference after orthoses intervention without Subject 14 removed

LIST OF QUOTES

- I can definitely feel a better transfer of energy through to the club head.
- It feels like I have a more stable base in my stance with the orthoses.
- Shot isn't bad without orthoses; it just doesn't feel as good.
- Unbelievable how much more balanced I am through the downswing.
- Definitely feel a lot more stable.
- Feel really stable on the downswing; I don't have to push through the swing as much.
- I can definitely feel it; it helps you get onto the balls of your feet slightly for better control.
- I'm not getting as much distance but ball flight feels better.
- I felt a lot more balanced.
- I felt as though I'm getting through the ball better.
- I feel like my heel's supported, it just feels right. My right heel used to click but that's stopped now.
- They feel a lot more comfortable.
- My golf's come on leaps and bounds.
- The orthoses definitely work.
- I used the simulator between sessions and noticed club head speed increasing.
- I didn't think they would make the slightest bit of difference but I'm amazed.
- I forgot they were there.

	Volunteer	Shot Perception	Club Head Velocity (mph)	Ball Speed (mph)	Launch Angle (°)	Azimuth (°)	Side Spin (rpm)	Back Spin (rpm)	Total Spin (rpm)	Peak Height (yds)	Descent Angle (°)	Ball Carry (yds)	Total Distance (yds)	Offline Accuracy (yds)	
Pre Orthoses	1	8	113	163	11	0	370	2742	2776	34	39	275	297	16	
	2	6	115	167	10	6	471	3025	3076	32	38	273	296	36	
	3	7	93	135	10	0	840	3149	3295	21	31	199	225	31	
	4	6	105	152	10	5	621	2592	2704	24	32	239	268	30	
	5	8	69	94	21	4	594	5371	5437	22	41	127	139	14	
	6	7	87	127	13	-2	554	3071	3173	23	33	189	215	21	
	7	7	83	121	16	-1	1005	4274	4527	26	37	158	183	24	
	8	5	80	116	13	2	1297	3492	3769	17	31	158	183	34	
	9	4	49	71	16	-5	1071	3659	3834	7	24	72	97	10	
	10	7	83	113	16	2	513	3650	3709	24	38	168	188	19	
	11	7	82	111	16	-1	886	2322	2503	20	32	164	192	31	
	12	6	75	109	14	1	1058	3432	3622	17	32	138	168	23	
	13	6	88	128	15	2	558	4189	4243	30	42	190	207	24	
	14	5	79	107	12	9	2121	4554	5201	14	28	135	157	38	
	15	6	63	91	17	-4	522	4149	4196	13	32	115	136	13	
	16	7	89	121	16	6	705	4945	5005	31	44	180	193	12	
	17	5	76	110	10	1	770	2446	2602	11	22	138	177	26	
	18	6	59	85	15	-2	1492	2361	2808	7	22	91	124	13	
	19	7	85	115	15	4	465	3767	3818	22	37	167	186	12	
	20	8	78	113	18	4	1447	6059	6254	29	45	155	167	11	
	21	6	60	81	10	-5	1655	2916	3470	5	14	70	111	9	
	22	7	76	104	13	7	1397	3813	4102	14	29	137	160	12	
	23	7	83	112	16	1	1118	5313	5440	24	39	152	169	22	
	24	7	80	116	15	2	342	5087	5105	24	40	164	179	11	
	25	7	80	116	16	14	1250	3335	3628	24	38	167	186	21	
	26	7	82	111	16	1	574	3428	3497	24	38	166	185	12	
Post Orthoses	1	10	115	167	10	2	470	2453	2512	31	36	283	308	15	
	2	7	118	172	10	5	370	3111	3149	37	41	283	303	21	
	3	8	97	141	9	2	724	2527	2656	17	25	207	244	36	
	4	8	106	153	13	6	664	2458	2574	34	38	256	279	16	
	5	7	70	101	20	1	483	5363	5393	24	43	136	149	8	
	6	7	91	132	9	-2	238	2017	2035	14	22	198	237	11	
	7	8	87	126	13	2	557	2830	2942	22	31	176	208	20	
	8	8	82	119	19	-1	752	4028	4131	28	40	171	191	18	
	9	7	51	74	19	2	1277	4001	4205	10	30	81	101	13	
	10	8	85	124	15	0	762	3603	3722	26	39	184	202	24	
	11	8	84	122	12	-1	460	2067	2138	16	26	176	212	25	
	12														
	13	8	92	133	12	1	550	3763	3824	26	37	200	220	23	
	14	8	84	122	14	6	859	3577	3723	24	37	181	200	16	
	15														
	16	8	90	131	15	6	844	4715	4793	32	44	188	202	5	
	17	7	78	113	11	0	433	1809	1886	12	22	154	194	16	
	18	8	65	94	11	-5	1757	2683	3224	7	18	101	138	11	
	19	8	89	121	17	2	802	4989	5056	31	45	175	188	8	
	20	9	88	120	12	6	838	5215	5316	21	37	166	183	14	
	21														
	22	8	77	112	13	8	1165	4149	4336	18	33	152	172	10	
	23	8	84	114	15	1	810	5121	5189	24	40	160	176	19	
	24	8	86	117	16	4	949	4777	4885	26	42	166	181	10	
	25	8	88	120	16	11	747	4202	4291	27	41	176	192	26	
	26	9	84	121	17	2	560	3693	3755	29	41	181	198	12	

Table 6. Subject average results - Pre & Post Orthoses.
Orange represents Superfeet Orange.
Green represents Superfeet Carbon.

Subject	Shot Perception	Club Head Velocity (mph)	Ball Speed (mph)	Launch Angle (°)	Azimuth (°)	Side Spin (rpm)	Back Spin (rpm)	Total Spin (rpm)	Peak Height (yds)	Descent Angle (°)	Ball Carry (yds)	Total Distance (yds)	Offline Accuracy (yds)
1	10	115	167	10	2	470	2453	2512	31	36	283	308	15
2	7	118	172	10	5	370	3111	3149	37	41	283	303	21
3	8	97	141	9	2	724	2527	2656	17	25	207	244	36
4	8	106	153	13	6	664	2458	2574	34	38	256	279	16
5	7	70	101	20	1	483	5363	5393	24	43	136	149	8
6	7	91	132	9	-2	238	2017	2035	14	22	198	237	11
7	8	87	126	13	2	557	2830	2942	22	31	176	208	20
8	8	82	119	19	-1	752	4028	4131	28	40	171	191	18
9	7	51	74	19	2	1277	4001	4205	10	30	81	101	13
10	8	85	124	15	0	762	3603	3722	26	39	184	202	24
11	8	84	122	12	-1	460	2067	2138	16	26	176	212	25
12													
13	8	92	133	12	1	550	3763	3824	26	37	200	220	23
14	8	84	122	14	6	859	3577	3723	24	37	181	200	16
15													
16	8	90	131	15	6	844	4715	4793	32	44	188	202	5
17	7	78	113	11	0	433	1809	1886	12	22	154	194	16
18	8	65	94	11	-5	1757	2683	3224	7	18	101	138	11
19	8	89	121	17	2	802	4989	5056	31	45	175	188	8
20	9	88	120	12	6	838	5215	5316	21	37	166	183	14
21													
22	8	77	112	13	8	1165	4149	4336	18	33	152	172	10
23	8	84	114	15	1	810	5121	5189	24	40	160	176	19
24	8	86	117	16	4	949	4777	4885	26	42	166	181	10
25	8	88	120	16	11	747	4202	4291	27	41	176	192	26
26	9	84	121	17	2	560	3693	3755	29	41	181	198	12

Table 7. Subject average change after orthoses intervention (Post orthoses intervention - Pre orthoses intervention)

Sheet 1 - page 1**Informed Consent Form
For Experimental Participants**

*Please read the following information carefully.
You can also request a copy for future reference.*

Experiment: Effects of Foot Orthotics on Performance and Comfort in Golf

Experimenters: Matthew Robinson

Affiliation: University of Loughborough, Solutions4Feet, Superfeet

DESCRIPTION: You are invited to participate in a research study that investigates the effects foot orthoses have on performance and comfort during 18 holes of golf, and the performance using a golf simulator. In the experiment, you will be asked to play 3-5 rounds of golf before completing a questionnaire regarding your comfort whilst playing golf and recording your scores. You will then be asked to complete a 30 minute golf simulator session, during which you will take up to 15 shots without orthotic insoles, and 15 shots with orthotic insoles. You will be asked to then wear the orthotic insoles in your golf shoes while playing another 3-5 rounds of golf, again completing the questionnaire regarding your comfort and recording your scores. You will finally complete a further 20 minute golf simulator session, taking up to 15 shots with orthotic insoles. This will allow us to compare performance and comfort before and after the use of orthotic insoles.

RISKS AND BENEFITS: The GC2 golf simulator will be used during this study. There are no known risks associated with the use of this simulator. Orthotic insoles will be worn in your golf shoes during this study. There are no known risks associated with wearing orthotic insoles; they are designed to do no harm. If for any reason you get discomfort in your feet that you did not get before the introduction of the orthotic insoles, you may remove the insoles for the rest of the round. Please then place them back into your golf shoes for the next round of golf and only take them out if the discomfort reoccurs. The insoles can take a little time to break in so only wear them in your golf shoes while playing golf, do not use them in your day-to-day shoes. Benefits from the study include results from the golf simulator sessions, a chance of improved comfort and improved performance whilst playing golf.

Sheet 1 - page 2

TIME INVOLVEMENT: Your participation will take approximately 30 minutes for the first golf simulator session, 20 minutes for the second golf simulator session. You will also play at least 6 rounds of golf over the course of the study.

SUBJECT'S RIGHTS: If you have read this form and have decided to participate in this experiment, please understand your participation is voluntary and you have the right to withdraw your consent or discontinue participation at any time without penalty. You have the right to refuse to answer particular questions. Your individual privacy will be maintained in all published and written data resulting from the study.

If you agree with the above-stated conditions and are willing to participate in the experiment, please sign below. By signing the form, you confirm that you meet the following conditions:

- **You do not currently wear orthotic insoles in your golf shoes.**
- **You have read the above consent form, understood it and you agree to it.**
- **You want to participate in the above-mentioned experiment.**

Name:

Date:

Signature:

Sheet 2 - rounds 1-5 have the same page as below

Comfort Questionnaire

Name:

Round 1:

Do you have any muscle aches or pains? If so where and how painful would you rate them on a scale of 0-10? (0 being no pain, 10 being unbearable pain)

Do you suffer from blistering, if so where and how painful would you rate them on a scale of 0-10? (0 being no pain, 10 being unbearable pain)

How would you rate your performance during this round of golf on a scale of 0-10? (0 being awful, 10 being perfect)

Round 2:

Do you have any muscle aches or pains? If so where and how painful would you rate them on a scale of 0-10? (0 being no pain, 10 being unbearable pain)

Do you suffer from blistering, if so where and how painful would you rate them on a scale of 0-10? (0 being no pain, 10 being unbearable pain)

How would you rate your performance during this round of golf on a scale of 0-10? (0 being awful, 10 being perfect)

Sheet 3

Did you feel the orthotics improved your performance over a round of golf?

Did you feel the orthotics improved your comfort over a round of golf?

Did you feel the orthotics reduced your fatigue over a round of golf?

Did you feel your swing was improved by the orthotics?

Did you feel more stable throughout the swing with the orthotics?

Would you recommend the orthotics to others for use in their golf shoes?

Do you have any further comments about the orthotics or the study?
