The Effects of Unilateral Ankle Bracing on Objective and Subjective Functional Performance in Basketball Players

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Introduction

Basketball is a multidirectional sport that involves explosive activities such as sprinting, rapid changes of direction and jumping; all which occur in a confined area amid multiple competitors. As such, it is easy to understand why ankle injuries, particularly inversion sprains, are the most common musculoskeletal injuries, and are a frequent occurrence amongst basketball players at all levels. A recent longitudinal study performed by Dick et al. (2007) discovered that ankle sprains were by far the most common injury in collegiate men’s basketball, accounting for just over 26% of all injuries sustained. At the professional level, ankle sprains are again the most frequently occurring injury for both men and women, totaling 9.4% and 13.7% respectively (Starkey, 2000 and Deitch et al, 2006). Inversion trauma is so commonplace in the sport that “more than 90% of elite players (report) a history of at least 1 ankle sprain” and the “incidence of recurrent ankle sprains has been reported to exceed 75% among basketball players at various levels of competition” (Dick et al, 2007).

Although often viewed as a relatively minor injury, in which less than 44% of injured athletes seek professional treatment (McKay et al, 2001), ankle sprains can have both immediate and long-term consequences. Dick et al. (2007) found that ankle sprains were the second most common injury requiring 10+ days of activity time lost, accounting for around 17% of all “severe” injuries. In concordance with this, McKay et al. (2001) state that of the 37 players suffering an ankle injury, “almost half (missed) one week or more of competition”. Even after the athlete returns to competition, an inversion trauma can have lingering effects, as “approximately 40-75% of individuals suffering from a lateral ankle sprain may develop residual symptoms or chronic ankle dysfunction” such as pain during activity, recurrent swelling, a feeling of giving way and repetitive injury (Gerber et al as quoted in Wikstrom, Tillman and Borsa, 2005).

To make matters worse for an athlete suffering a sprained ankle, previous ankle injury has been suggested as the largest factor for future injury. According to McKay et al, “players with a history of ankle injury were almost five times more likely to sustain an ankle injury than previously non-injured players” (2001). While not all authors are convinced of such a strong correlation, ankle sprains have been linked to ankle proprioception deficits, which can take 3 to 6 months to improve post-injury (Akabari et al, 2006). And, “results indicate that various proprioceptive deficits at the ankle joint are predictors of ankle injury”, as is functional instability (Payne, Berg and Latin, 1997).

Thus, it stands to reason that interventions that help prevent ankle injury, or reduce the likelihood of re-injury would be highly favourable to basketball athletes. The potential benefits of ankle taping or bracing have been well documented and the findings “generally provide support for the role of strapping and bracing in reducing the incidence of injuries” Hopper, McNair and Elliott, 1999). Metcalfe et al (1997) suggest that “the use of prophylactic ankle taping applications and devices is associated with decreased incidence of injury in basketball and football. A review of literature performed by Wilkerson (2002) concluded that “although the relative effectiveness of taping versus bracing for restraint of excessive inversion has not been clearly established, both types of ankle support clearly provide beneficial protective effects. When cost, comfort and ease of application are taken into consideration, bracing appears to be superior to taping. A study done by Paris (1992) showed that “when braces are substituted for tape, a net saving of 63.2% can be made during a basketball season”. Along the same lines, a cost benefit analysis concluded that “ankle bracing, therefore, may be a better way to provide the support necessary to prevent ankle sprains” (Olmsted et al, 2004).

Despite these findings, many basketball athletes choose not to brace their ankles. Fear of losing functional ability and/or losing muscular control and becoming dependant on the brace for stability are athlete concerns that have not been fully answered. Some studies show that vertical jump and agility are significantly reduced (Paris, 1992 and Metcalfe et al, 1997). While other studies “indicate that no significant performance impairment is caused by semirigid or soft braces in a high intensity, short duration agility course” (Rosenbaum et al, 2005). A meta-analysis of the research regarding functional ability and bracing suggests that “the average effects of external ankle support on sprint,
agility, and vertical jump performance ranged from trivial to small in subjects who are not elite athletes” but also warns that “it is likely, however, that the true effects of these ankle support conditions will be larger in some individuals” (Cordova et al, 2005). However, most of the studies were performed with “older” styles of braces and little literature can be found regarding the effects of bracing over a period of time on active stability, functional ability or the athletes’ subjective opinions. Thus, the purpose of this study is fourfold: (1) to determine if bracing the ankle of the dominant leg over a period of 6 weeks reduces active stability in developmental basketball players, (2) to determine if bracing the ankle of the dominant leg for a period of 6 weeks causes adaptive increase in active stability in the non-braced leg, (3) to determine if bracing the ankle of the dominant leg affects functional ability in developmental basketball players and whether the effect is increased or decreased after a period of 6 weeks, and finally (4) to determine what the subjective opinions are before, during and after 6 weeks of ankle bracing in developmental basketball players.

After reading the literature, our hypotheses are that (1) wearing an ankle brace for 6 weeks will not create any significant difference in active ankle stability in either the braced or non-braced leg versus the control group, (2) Initially, bracing the ankle will create functional deficits, but these deficits will disappear after 6 weeks and (3) the subjective opinions of the athletes wearing the brace will reflect that functional deficits have disappeared after 6 weeks.

Methods

Subjects
All members of the Palaimon Korinthos youth development team were asked to volunteer for the study and from this 12 players met the inclusion criteria and were selected. All players were male and between the ages of 13-16 years of age. Prior to inclusion in the study, volunteers who passed the exclusion criteria were verbally informed of the procedures of the study and asked to fill out the Informed Consent/Agreement form. Upon agreement, subjects were randomly allocated into groups by drawing lots. As playing time and position may have significant influences on the forces placed on the ankle joint groups were stratified to ensure equal number of starters and of post/perimeter players. Following this, the 2 groups were then randomly assigned as the test group and the control group, again by drawing lots.

The inclusion criteria for this study were: athletes who were not currently taping or wearing an ankle brace during practice or games, who have not taped or worn an ankle brace during training/games for longer than 3 weeks consecutively at any time in the past, who have not sustained an ankle injury that caused him miss at least 1 practice or game in the past 6 months and who were able to attend at least 80% of the practices.

The 2 groups were similar at baseline in regards to age (14.67±1.03yrs for control and 14.67 ±0.82yrs for test group), height (177.67 ±9.33cm and 174.83 ±11.53cm) and weight (71.83 ±7.19kg and 73.67 ±7.39kg). All subjects completed the SEBT, but 1 player dropped out prior to the final round of functional testing; due to being cut from the team.

Procedure
We examined the effects of wearing an ankle brace unilaterally on the dominant leg for 6 weeks on active stability (as measured by the Star Excursion Balance Test [SEBT]) and on functional ability. Functional ability was tested through jumping ability, speed, agility (as measured by the “T” test), and shooting percentage. Jumping ability was split into jump height (measured by the vertical jump test) and jump length (measured by the single leg triple hop). The treatment group wore an ankle brace on their dominant leg during practices and games from Nov. 6, 2007 until Dec. 19, 2007, and the control group remained un-braced during that time. The dominant leg was determined by asking each subject which leg he prefers to kick a ball with. The leg he stated was considered to be the dominant leg. The 2 groups were tested on 2 separate occasions, once at the start of the study, and
once after a period of 6 weeks. Each round of testing occurred over 4 days at their practice facility and occurred following their pre-practice warm-up.

The SEBT was performed on both the dominant and non-dominant legs, without the braces on. For the functional tests, all tests were performed with the braces on and with them off. To ensure fatigue and/or learning was not a factor, half the test group began each test while wearing the brace and the other half began each test without the brace. In addition, when the dominant leg was tested twice, the non-dominant leg was tested in-between the dominant leg trials. The control group performed an equivalent number of trials to the test group on each test.

In addition to this we examined our subjects subjective opinions about ankle bracing by having them fill out questionnaires about their perceived abilities before and after wearing the braces. Three questionnaires were completed by the treatment group: one prior to testing assessing their opinions about comfort and how wearing a brace might affect their functional performance, one immediately following the first round of testing assessing their perceptions of comfort and how bracing affected their performance and one following the final round of testing assessing their perceptions after 6 weeks.

**Brace**

The brace used in this study was the PSB Ankle Brace by Push Braces. This brace was selected because it is a relatively new design (2000), specifically marketed as a “sport brace”, and claims that it “does not inhibit normal movement while providing optimal support for the ankle joint” (pushstore.com). To ensure proper use of the braces, one of the testers (VV) attended product training prior to the study. After the allocation process the testers gave a demonstration about the use of the brace to the test group. They also ensured proper fit and application when the subjects first tried on the braces. Following this, one tester was present at the beginning of each practice for the first 2 weeks, and then once a week, to ensure proper use of the brace and to answer any questions.

**Star Excursion Balance Test**

The SEBT is an active test designed to measure dynamic stability of the lower limb, and has been found to “appear to be sensitive in detecting reach deficits both between and within athletes with unilateral chronic ankle instability” (Olmsted et al, 2002). The SEBT has been claimed to have “high intertester reliability (interclass correlations of .78 to .96) intratester reliability (intraclass correlation coefficients = .78 to .96) and fair to good validity (r = .42 to .79)” (Bressel et al, 2007). Protocol for the SEBT was taken from Olmsted et al (2002). The SEBT was performed with the subject standing at the centre of a grid placed on the floor, with 8 lines extending at 45º increments from the centre of the grid. The grid was constructed using a carpenter’s triangle, a laser-level and 5cm-wide adhesive tape and was enclosed in a 3m by 3m square on the hardwood floor, and distances of each half centimetre were marked on the tape. A verbal and visual demonstration of the testing procedure was given to groups of 2 subjects by the testers. Although 6 practice trials are recommended, due to time constraints, each subject completed 3 practice trials in all directions on each leg. To perform the test, subjects stood in the middle of the grid with their toes behind a marked line 10cm from the center. The subjects stood on one leg while reaching with the opposite leg as far as possible in the desired direction. They then lightly touched the furthest point possible on the line with the most distal part of their reach foot. The touch was to be as light as possible to ensure the centre of gravity was maintained over the stance foot and stability was not enhanced with the reaching foot. The reaching foot was then brought back to the centre before reaching in the next direction. Directions were recorded in reference to the stance foot as anterior-lateral (AL), anterior (A), anterior-medial (AM), medial (M), posterior-medial (PM), posterior (P), posterior-lateral (PL) and lateral (L). For reliability, a blinded external assessor (Pa. L) manually measured the distance touched to the nearest half centimetre. Three reaches in each direction were recorded and the average of the 3 reaches for each leg in each of the 8 directions was calculated. The directions were followed in sequence, but the order of the sequence (clockwise or counter clockwise) and the starting direction were altered to prevent learning from occurring. Trials were omitted and repeated if the subject placed any other limb on the ground for balance, lifted the stance foot from the floor at any point, or was unable to
return the reach leg all the way back to the starting position without contacting the floor again. Trials were also omitted and repeated if the testers deemed the subject shifted weight onto the reaching foot while touching the furthest point. For practice and testing, subjects were allowed to wear socks but not shoes. As done by Bressel et al (2007), scores for all distances were normalized to leg length (reach distance/leg length X 100 = percentage of leg length). This was done to ensure changes were not due to potential growth of the subject. Leg length of each subject’s dominant and non-dominant leg was measured prior to the initial and final testing rounds. Subjects lay supine and were measured using a flexible tape measure from the top of the anterior superior iliac spine (ASIS) to the bottom of the medial malleolus.

As done by Bressel et al (2007), scores for all distances were normalized to leg length (reach distance/leg length X 100 = percentage of leg length). This was done to ensure changes were not due to potential growth of the subject. Leg length of each subject’s dominant and non-dominant leg was measured prior to the initial and final testing rounds. Subjects lay supine and were measured using a flexible tape measure from the top of the anterior superior iliac spine (ASIS) to the bottom of the medial malleolus.

Vertical Jump Test
This was based on the Sargent jump test, but was modified to be a single leg jump as bracing was unilateral. A black board measuring height to the nearest half centimetre was hung on the wall. Prior to the test, a verbal and visual demonstration was given by the testers to groups of 3 subjects and 1 practice trail on each foot was performed. The subjects stood behind a line 20cm from the wall with the side of the non-jumping leg facing the board. They then reached up with the hand closest to the wall; keeping the jump foot flat on the ground and lifting the other. The subjects reached up as high as possible on the board and the height they were able to reach with their furthest fingertip was recorded. The subjects then chalked their fingers, stood on the jump foot and jumped as high as possible, using a dynamic start with sudden knee-dip and arm swing to assist in projecting the body upwards. All jumps were executed with the attempt of attaining maximum height with no restrictions being placed on the magnitude of their countermovement. The subjects were instructed to touch the wall at the highest point of the jump and the chalk was used to indicate this point. Two trials of three attempts were done with the dominant leg (1 while wearing the brace and 1 without the brace in the test group) and one trial (3 attempts) was performed with the non-dominant leg. The non-dominant leg was tested in-between trails of the dominant leg. One tester (GK) manually recorded all reach and jump heights. The other tester (VV) digitally recorded all jump heights using a digital video camera standing on a platform 3m from the wall. The practice jump was used to set the height of the camera to be as perpendicular to the jump height as possible. The official jump heights were taken from the video recordings. The best of three attempts was recorded and the difference between the reach height and the jump height was calculated.
Single Leg Triple Hop
This test was chosen to determine jumping distance and the triple hop was chosen over a single jump because, although it may not be more functional, we felt it would be more sensitive in ascertaining potential differences. A fixed starting point was marked with a piece of 5cm wide adhesive tape placed on the hardwood floor. A distance extending 4m was then marked at every half-centimetre using a measuring tape on 5cm wide adhesive tape and began 3m from the starting point. Prior to testing, a verbal and visual demonstration was given by the testers to groups of 3 subjects, and one practice jump was performed on each leg. To begin the test, subjects stood stationary on one leg (jump leg) behind the starting point and then proceeded to hop three consecutive times as far as possible on the same leg. Although they were required to begin with one foot stationary on the ground, no limitation was placed on the amount of pre-swing or counter-movement prior to the jump. The subjects wore shoes and were instructed to hop as far as possible. The distance reached with the furthest part of the shoe after 3 hops was recorded. Each trial consisted of three attempts. Two trails were performed with the dominant leg (one with the brace and one without) and 1 trial was performed with the non-dominant leg, in-between the dominant leg trials. The maximum distance achieved during each trial was taken. One tester (GK) manually recorded all distances. The other tester (VV) digitally recorded all jumps using a tripod-mounted video camera positioned 2m from, and facing perpendicular to the marked tape. The practice jump was used to position the proper distance of the camera from the starting point and the camera was not moved during each trial. The official jump distances were taken from the video recordings and the manual recordings were reserved as back-up.

2 Court Length Sprint Test
A sprint test covering two court lengths and involving a quick change in direction was used as a measure of speed as we considered it to be more functional for basketball than straight line sprinting alone. To perform the test, a line was marked on the wall with a volleyball antenna indicating the exact position of the starting/finishing point, and was placed using a laser-level positioned on the baseline. A tripod mounted digital video camera was placed on directly on the baseline 3m away from, and facing the marked starting/finishing line. Prior to testing, a demonstration was given to the entire group and one practice trail was performed. Subjects began by standing stationary behind the starting line. On the command “Go”, they sprinted as fast as possible and touched the far baseline with the foot of their choice. They then turned and sprinted back as fast as possible past the finish line. Subjects were informed to continue sprinting past the finish line and not begin decelerating before they reached it. Time was recorded using a digital stop watch and began on the command “Go” and finished when any part of the subjects body, other than their limbs, crossed the finish line. Frame by frame review of the video recordings were used to determine the exact finish time and were recorded to the nearest hundredth of a second. If a subject failed to touch the far baseline or reported slipping, then the trial was discarded and repeated.

T-Test
The T-test was selected as the test to measure basketball related agility because it includes sprinting, quick change of directions, defensive sliding (sidestep) and back peddling, all of which are important in the sport. According to Pauole et al (2000) “the intraclass reliability of the T-test was 0.98 across 3 trials” and thus, “appears to be highly reliable and measures a combination of components, including leg speed, leg power, and agility”.

Three cones (B, C and D) were placed in a horizontal line 4.55m apart from each other, and the cones were positioned 9.1m away from the starting point (A) using a tape measure and a laser level. The line created by A and B
perpendicularly intersected the line created by B, C and D to form a “T” (see diagram 2).

Prior to testing, a verbal and visual demonstration was given to a group of 6 subjects by the testers, and each subject performed 1 practice trail. The test was performed as follows: (1) on the command “Go” subjects sprinted from the start/finish line (A) to cone B touching it with the hand of their choice, (2) they then sidestepped leading with their left foot and touched cone C, (3) then, leading with the right foot, they sidestepped and touched cone D, (4) they then sidestepped back to cone B (left foot lead), touched it and then (5) back-pedalled across the start/finish line. A tri-pod mounted digital camera was placed parallel on the start/finish line and the finish line was marked with a volleyball antenna on the wall using a laser level. Time started on the “Go” command and was stopped as soon as any part of the subject other than a limb crossed the finish line. Time was recorded to the nearest hundredth of a second and frame by frame review of the video recordings was used to determine the exact finish time. If a player reported slipping, then the trial was omitted and repeated.

**Shooting Percentage**

Five locations were marked on the court using 5cm wide adhesive tape. All spots were positioned 5.25m from the basket. Two of them were placed 1m above the baseline on both sides of the court. Two of them were placed where the volleyball court intersected the 3-point line (1m inside) on both sides of the court. And one spot was marked on a line that connects the two baskets. Players shot in groups of three, alternating shooters after each attempt, and each subject took ten shots before moving to the next position. Shots were taken by each subject at every spot, accounting for fifty shots each. While one group was shooting, another group of three rebounded. The total number of shots made by each player was recorded.

**Results**

**SEBT**

When comparing the averages of the sum of the 8 reach directions between the dominant and non-dominant legs, the test group displayed no significant difference between them at initial testing (Dom= 96.53, Non-dom= 97.89; P= 0.22) or after 6 weeks (Dom= 101.16, non-dom= 101.09; P= 0.94).

While looking the average change in each limb after 6 weeks, the test group significantly increased reach distance in the dominant (+4.63, P=0.04) and non-dominant (+3.20, P=0.03) leg. No real difference in the average change between the 2 limbs existed (P=0.42).

Interestingly, while the control group also showed a tendency to increase in average reach in the dominant (+1.90) and non-dominant (+1.44) limbs, this change was not significant (P=0.33 and 0.44). The average change between them was also not significant (dom +1.42, P=0.42) (see fig. 2).
However, in comparing the 2 groups, no significant differences were found between them at initial testing, or after 6 weeks in regards to average reach distance in the dominant and non-dominant legs. There was also no significant difference in the average change after 6 weeks between the groups (see table 1).

Table 1: Comparison average reach between both groups (Scores are in % leg length)

<table>
<thead>
<tr>
<th></th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Reach Dom</td>
<td>Control</td>
<td>6</td>
<td>91.95</td>
<td>6.70</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Test</td>
<td>6</td>
<td>96.53</td>
<td>3.77</td>
<td></td>
</tr>
<tr>
<td>Dom Average after 6</td>
<td>Control</td>
<td>6</td>
<td>93.86</td>
<td>7.25</td>
<td>0.08</td>
</tr>
<tr>
<td>weeks</td>
<td>Test</td>
<td>6</td>
<td>101.16</td>
<td>5.45</td>
<td></td>
</tr>
<tr>
<td>Dom Average Change</td>
<td>Control</td>
<td>6</td>
<td>+1.90</td>
<td>4.34</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>Test</td>
<td>6</td>
<td>+4.63</td>
<td>3.98</td>
<td></td>
</tr>
<tr>
<td>Non dom Average</td>
<td>Control</td>
<td>6</td>
<td>94.41</td>
<td>8.43</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>Test</td>
<td>6</td>
<td>97.64</td>
<td>4.23</td>
<td></td>
</tr>
<tr>
<td>Non dom after 6</td>
<td>Control</td>
<td>6</td>
<td>95.85</td>
<td>8.60</td>
<td>0.20</td>
</tr>
<tr>
<td>weeks</td>
<td>Test</td>
<td>6</td>
<td>101.09</td>
<td>3.66</td>
<td></td>
</tr>
<tr>
<td>Non dom Change</td>
<td>Control</td>
<td>6</td>
<td>+1.44</td>
<td>4.17</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>Test</td>
<td>6</td>
<td>+3.45</td>
<td>2.34</td>
<td></td>
</tr>
</tbody>
</table>
When different directions are taken into account, the two groups did display differences. The test group showed significant increases after 6 weeks in the PL (+6.25, P=0.03) and L (+12.53, P=0.00) directions for the dominant leg and in the M (+5.42, P=0.01), PL (+5.12, P=0.05) and L (+5.13, P=0.03) directions for the non-dominant. On the other hand, the control group demonstrated no significant change in any direction for either leg (see Fig. 3).

**Fig. 3:** Average reach in each direction

Yellow highlight indicates statistical significance

### Functional Tests

When comparing the average performances of the functional tests when braced vs. non-braced, the experimental group showed no significant differences, either initially or after 6 weeks (see Table 2).

#### Table 2: Functional tests of the Experimental group with and without the brace on

<table>
<thead>
<tr>
<th>Test</th>
<th>Brace (sec)</th>
<th>Non-brace (sec)</th>
<th>Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprint</td>
<td>10.44 ±0.4</td>
<td>10.38 ±0.5</td>
<td>0.08</td>
<td>0.70</td>
</tr>
<tr>
<td>Sprint after 6</td>
<td>10.53 ±0.5</td>
<td>10.41 ±0.3</td>
<td>0.12</td>
<td>0.20</td>
</tr>
<tr>
<td>&quot;T&quot; test</td>
<td>11.39 ±0.5</td>
<td>11.45 ±0.6</td>
<td>0.06</td>
<td>0.81</td>
</tr>
<tr>
<td>&quot;T&quot; after 6</td>
<td>11.23 ±0.4</td>
<td>11.30 ±0.2</td>
<td>0.07</td>
<td>0.59</td>
</tr>
<tr>
<td>V jump</td>
<td>33.42 ±3.9</td>
<td>32.58 ±3.0</td>
<td>0.84</td>
<td>0.22</td>
</tr>
<tr>
<td>V jump after 6</td>
<td>33.30 ±5.3</td>
<td>32.80 ±5.4</td>
<td>0.50</td>
<td>0.45</td>
</tr>
<tr>
<td>3 jump</td>
<td>45.5 ±34.2</td>
<td>588.00</td>
<td>4.33</td>
<td>0.69</td>
</tr>
<tr>
<td>3 jump after 6</td>
<td>544.2</td>
<td>553.4</td>
<td>9.20</td>
<td>0.46</td>
</tr>
<tr>
<td>Shooting</td>
<td>20.33 ±7.6</td>
<td>19.33 ±5.7</td>
<td>1.00</td>
<td>0.47</td>
</tr>
<tr>
<td>Shooting after 6</td>
<td>23.60 ±6.0</td>
<td>23.00 ±5.8</td>
<td>0.60</td>
<td>0.73</td>
</tr>
</tbody>
</table>

On the other hand, when looking at the differences after 6 weeks in the experimental group, there was a significant decrease in triple hop distance of the dominant leg, both when braced (−40.6, P=0.02) and when non-braced(−36.0, P=0.00). No other significant changes were noted (see Table 3).

#### Table 3: Functional Tests Of the Experimental Group Initially and After 6 Weeks

<table>
<thead>
<tr>
<th>Test</th>
<th>Initial</th>
<th>After 6</th>
<th>Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprint B</td>
<td>10.45 ±0.4</td>
<td>10.53 ±0.5</td>
<td>−0.08</td>
<td>0.28</td>
</tr>
<tr>
<td>Sprint nB</td>
<td>10.26 ±0.5</td>
<td>10.41 ±0.3</td>
<td>−0.15</td>
<td>0.33</td>
</tr>
</tbody>
</table>
As it concerns the control group, the athletes did not present any significant difference in any of the functional tests, when their initial performance was compared to their performance after 6 weeks (see Table 4).

Table 4: Functional Tests Of the Control Group Initially and After 6 Weeks

<table>
<thead>
<tr>
<th>Test</th>
<th>Initial</th>
<th>After 6</th>
<th>Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprint</td>
<td>10.47 ±0.8</td>
<td>10.44 ±0.8</td>
<td>0.03</td>
<td>0.83</td>
</tr>
<tr>
<td>&quot;T&quot; test</td>
<td>11.34 ±0.7</td>
<td>11.31 ±0.9</td>
<td>0.02</td>
<td>0.92</td>
</tr>
<tr>
<td>V jump</td>
<td>32.08 ±5.9</td>
<td>32.96 ±7.8</td>
<td>-0.88</td>
<td>0.75</td>
</tr>
<tr>
<td>V jump nD</td>
<td>35.83 ±4.6</td>
<td>35.33 ±5.8</td>
<td>0.50</td>
<td>0.74</td>
</tr>
<tr>
<td>3 jump</td>
<td>576.50</td>
<td>579.50</td>
<td>3</td>
<td>0.70</td>
</tr>
<tr>
<td>3 jump nD</td>
<td>566.75</td>
<td>591.00</td>
<td>-24.25</td>
<td>0.28</td>
</tr>
<tr>
<td>Shooting</td>
<td>25.00 ±6.3</td>
<td>24.67 ±3.6</td>
<td>0.33</td>
<td>0.84</td>
</tr>
</tbody>
</table>

The comparison between the control and experimental group for each functional test is as follows: Sprinting- no significant difference initially (braced 0.02, P=0.95), (non-braced 0.09, P=0.81) or after 6 weeks (braced -0.09, P=0.83), (non-braced 0.03, P=0.93) (see fig. 4).

T-Test- no significant difference initially (braced -0.05, P=0.89), (non-braced -0.11, P=0.79) or after 6 weeks (braced 0.09, P=0.85), (non-braced 0.02, P=0.97) (see fig. 5).
Vertical jump- no significant differences in either leg initially (braced -1.33, P=0.65), (non-braced -0.50, P=0.86), (non-dominant 2.58, P=0.45) or after 6 weeks (braced -0.34, P=0.94), (non-braced -0.84, P=0.84), (non-dominant 0.03, P=0.99) (see fig. 6).

Triple Hop- no significant differences in either leg initially (braced -15.83, P=0.59), (non-braced -11.50, P=0.67), (non-dominant 3.50, P=0.92) or after 6 weeks (braced 35.30, P=0.20), (non-braced 26.10, P=0.35), (non-dominant 29.40, P=0.43) (see fig. 7).

Shooting- no significant difference initially (braced 4.67, P=0.27), (non-braced 5.67, P=0.13) or after 6 weeks (braced 1.07, P=0.72), (non-braced 1.67, P=0.57) (see fig. 8).
Subjective Questionnaires

No trends in the questionnaires were readily noticeable. At the beginning of the study, the majority of the subjects (9/12 total and 6/6 of the experimental group) believed that wearing a brace would make them slightly-much quicker when changing directions. All other questions about functional ability were split and in general the majority believing that wearing a brace would have no effect on performance. The reasons given for not currently wearing a brace were: No current problems with ankles (7), Wore a brace in the past and it was uncomfortable (2), Believe wearing a brace would be uncomfortable (1), and Not informed (1).

After trying the brace on and performing the functional tests, changes in the experimental group showed a trend from believing wearing a brace would make them slightly quicker when changing directions (1) to no difference (4) or slightly slower (1). 2 subjects also felt slight restriction in mobility when wearing the brace who had previously believed that no restriction would be felt.

After wearing the brace for 6 weeks, no noticeable trends in regards to changes in functional ability were noted, though 1 player felt the brace was more uncomfortable. Of the 5 subjects remaining in the experimental group, 2 subjects chose to continue to wear the brace, 1 chose not to continue wearing but would use it if he suffered an ankle injury, and 2 chose that they would never wear any brace. The reasons given for continuing to wear the brace were that their ankle feels more stable with it (2) and the reasons for not continuing to wear the brace were that it has no use (2) and that it is uncomfortable (1).

Discussion

Even though it seems widely accepted that wearing an ankle brace reduces the risk of ankle injury, arguments remain over whether bracing an ankle over a period of time has detrimental effects on the athlete. The results of our study show that wearing an ankle brace on the dominant foot over a period of 6 weeks does not reduce stability of that leg, nor does it create compensation, in regards to active stability, in the opposite leg. If a reduction in reach distance of the braced leg were to be seen, we would have expected it to be in the medial/lateral direction, as most braces try to protect against forces in this direction. However, the test group actually showed significant improvement in the lateral and posterior-lateral direction on the dominant foot, while the control group did not (neither group showed change in the medial direction). As it concerns the non dominant foot, only the test group showed statistically significant improvement in active stability after 6 weeks, which occurred in both the braced (dominant) and non-braced (non-dominant) limbs; though the significance disappears when compared against the control group.

These results are in concurrence with recent studies that have demonstrated that use of ankle braces over a period of time did not diminish dynamic postural control, the magnitude of the peroneus longus stretch reflex or muscle activation around the ankle joint (Cordova and Ingersoll, 2003; Crocket, 2007, Gribble et al., 2005). Thus it appears that wearing a brace on a healthy ankle does not
create dependency upon it, and therefore can be discontinued at any time without negative effects on stability. If this is the case, then it allows the athlete to be able to try-out, or continue to wear braces without fear of weakening the ankle.

Our results also show that wearing an ankle brace does not inhibit performance in most of the basketball specific tests. On comparison between the groups there are no significant differences in any of the five functional tests, initially or after 6 weeks. Thus, wearing the brace did not lead to a drop in performance in relation to the control group. This is supported by other studies. Paris (1992) found that there were no significant differences in speed, balance, agility or vertical jump while wearing a McDavid ankle brace. Rosenbaum et al. (2005) concluded that “no significant performance impairment is caused by semi-rigid or soft braces in a high intensity, short duration agility course”. And a meta-analysis on functional performance and bracing suggested that “the average effects of external ankle support on sprint, agility, and vertical jump performance ranged from trivial to small in subjects who are not elite athletes” (Cordova et al., 2004).

When looking at the test group specifically, they did not show any significant difference initially, between performance while wearing and not wearing the brace during sprinting, vertical jump, triple hop, agility or shooting; the same holding true after 6 weeks. Therefore, using the brace for the first time did not influence ability, and this did not change after a period of 6 weeks, suggesting that an adaptation period to become accustomed to the brace may not be required.

However when examining the change in performance after 6 weeks, some differences did arise. Four out of the five functional tests seem not to be influenced by the application of the brace on the dominant leg after a period of 6 weeks. But, the distance jumped on the dominant leg during the triple hop test significantly decreased. Interestingly, this change occurred both with the brace on and with it off. This appears to suggest that while the athletes are not becoming dependant on the brace, perhaps some power, stability or coordination in the dominant leg has been lost. Yet, this contradicts the findings of the other functional tests, specifically the vertical jump and SEBT which also test aspects of power, stability (respectively) and coordination and also isolate the dominant leg. If there were loss of stability, we would have assumed to find a difference when the athletes were wearing the brace compared to when they were not, but this was not the case. It is also surprising since Crockett (2007) discovered no such changes in his study when examining single leg triple crossover hop or 6M single leg hop for time. While a triple hop is seemingly not so functional for basketball, we chose it as a test because we assumed it would be more sensitive in detecting changes than a single hop test. Thus, it is possible that changes have occurred and the triple hop test is the only one we performed that is sensitive enough to detect them, though we have found no statistics or claims in literature to support this. Another argument could simply be a drop in motivation. We had interrupted their practice schedule for four days and the triple hop was one of the last tests performed. The experimental group was forced to repeatedly put the brace off and on and of all the tests, the triple hop may perhaps be the least meaningful for the athletes.

In comparison, the control group did not show any significant difference after 6 weeks in performing any of the five functional tests. Hence, at this stage, their training routine did not cause increases in ability in any of the tests we used.

When looking at the questionnaires we were a bit surprised by the initial attitudes towards bracing. The majority seemed to believe that wearing a brace would not affect their functional performance, and in regards to agility, most believed that a brace would make them change directions quicker. Hence, the reasons given for not wearing a brace were more focussed on that there was no reason to start rather than a belief that it would affect their performance or that it would be uncomfortable. After wearing the brace for 6 weeks, attitudes tended to lean towards leaning towards bracing having no effect on functional performance. While we hypothesized that wearing a brace over this time might allow the subjects to become accustomed to the brace and create a feeling that it does not affect performance, we thought the initial attitudes might be a little more “negative”.
It is interesting to note that even though none of our subjects had worn a brace for more than 3 weeks consecutively in the past, 2 out of 5 subjects in the experimental group decided to continue wearing this brace. The reasons given for discontinuing were that it was either not useful and one subject found it uncomfortable.

The results of the star excursion balance test appear to strongly reinforce our hypothesis that wearing a brace over 6 weeks would not have influence on the active stability of either leg. However, although it has been claimed to have high reliability (Bressel et al., 2007), and we attempted to follow the protocol as closely as possible, we do question the reliability of the SEBT as we performed it; as reach distance appeared to differ quite substantially among some of the trials. This could be due to the fact that we had no criteria about how the foot should be positioned when reaching. Thus, we were forced to accept trials regardless of whether or not the subject pointed his toes or twisted his foot while reaching. Another confounding factor was that, due to time constraints at the gym, we were only able to complete 3 practice trials rather than the recommended 6.

Furthermore, the SEBT tests the active stability of the entire lower limb, and is not specific for the ankle joint. Our assumption was that wearing an ankle brace should have the greatest influence on the ankle joint and minimal to no influence on the other joints of the leg. As this has not been proven, different changes and compensations could be occurring amongst the different joints. And finally, the SEBT was found to be sensitive for detecting deficits in those with unilateral chronic instability, but our research studied “healthy” ankles. It is possible that this test is not sensitive enough to detect changes in healthy ankles. Future research using the SEBT, or that aims to study ankle stability, should take this into consideration.

Issues also arose during functional testing. For most of the functional tests we used video equipment in order to increase the reliability of our testing. However use of the video, as we attempted it, proved futile for the triple hop jump. There was a fairly large discrepancy in the distance jumped between trials, and as a consequence the positioning of our camera failed to record several of the jumps. As such, the visual recordings had to be used for multiple trials, reducing the reliability of the test.

Also, in general we executed the functional tests in groups of three. Since there were only two testers, we were unable to control the pre-test activity of the waiting subjects. Whether they properly completed the warm up prior to the test or had some fatigue before performing the warm up is questionable.

In addition, while we tend to believe the drop in performance in the triple jump may be more related to motivation than reduced ability, we do acknowledge that some loss of ability remains a possibility. Future studies should focus on using functional assessment tests that may be more sensitive in detecting discrepancies, and/or perform the study over a longer period, to determine if subtle changes are actually occurring.

Still, from our results and trends in current literature, we conclude that wearing an ankle brace on the dominant foot over 6 weeks does not reduce the active stability in that leg, nor does it create compensation, in regards to stability, in the other leg. Furthermore it seems that the performance in most of the basketball functional testing is not reduced when there is application of a brace on the dominant leg of a basketball player. Various studies suggest that some of the more rigid braces may affect elements of performance (Paris, 1992; Cordova et al., 2004), but we feel it is unlikely that an athlete without a history of ankle injury/problems would require the support of such rigid braces.

As physiotherapists, we are not advocating that every basketball athlete needs to be braced in order to prevent injury. Several recent studies have shown that stability/proprioceptive training can be effective in reducing the incidence of ankle injury; though there is some argument as to whether it is effective in previously uninjured ankles (Emery et al, 2007; Olsen et al, 2005; McGuire and Keene, 2006; Stasinopoulos, 2004; Verhagen et al, 2004). When possible, this may prove to be the more appealing route for many athletes. Nevertheless, for these programs to continue to be effective,
adherence is necessary, which will inevitably not always be case. Athletes will have to decide for themselves, and coaches/managers will have to decide the cost/effectiveness for their teams, of whether bracing, proprioception training, a combination of the two or no preventative measure is best suited for them.

From a physiotherapeutic point of view, braces could safely be used as an injury prevention measure in healthy ankles. If this option was chosen, attention should be focussed on presenting the potential benefits in order to increase the likelihood of an athlete trying bracing. And when selecting a brace, the comfort the athlete feels in the brace should not be overlooked.

Acknowledgements

We would like to thank the Palaimon Korinthos youth basketball team and our external assessor Panos Livathinos (Pa. L) for their participation and cooperation in our study. We would also like to thank Push Braces for donating the braces used in this study.

Works Cited


Appendix A: Questionnaire 1

Please circle the answer that best represents your opinion
Please only circle 1 answer per question

1) When running on the court, I believe wearing an ankle brace would make me run:
   a. Much faster
   b. Slightly faster
   c. No difference than without the brace
   d. Slightly slower
   e. Much slower

2) I believe wearing an ankle brace would make me jump:
   a. Much higher
   b. Slightly higher
   c. No different than without a brace
   d. Slightly lower
   e. Much lower

3) I believe that wearing an ankle brace would make me jump:
   a. Much further
   b. Slightly further
   c. No different than without a brace
   d. Slightly less distance
   e. Much less distance

4) When quickly changing directions while playing basketball, I believe wearing an ankle brace would make me:
   a. Much quicker
   b. Slightly quicker
   c. No difference than without a brace
   d. Slightly slower
   e. Much slower

5) I believe wearing an ankle brace would affect my shooting ability by:
   a. Greatly increasing my shooting percentage
   b. Slightly increasing my shooting percentage
   c. No different than with no brace
   d. Slightly decreasing my shooting percentage
   e. Greatly decreasing my shooting percentage
6) I believe that wearing an ankle brace while training or playing will cause me to:
   a. Fatigue much less quickly
   b. Fatigue slightly less quickly
   c. No difference in fatigue rate when compared to no brace
   d. Fatigue slightly more quickly
   e. Fatigue much more quickly

7) I believe that wearing a brace while training or playing would be:
   a. Much more comfortable than without a brace
   b. Slightly more comfortable than without a brace
   c. No different in comfort than without a brace
   d. Slightly less comfortable than without a brace
   e. Much less comfortable than without a brace

8) I believe that wearing an ankle brace while training or playing would restrict the mobility in my ankle:
   a. NO, no restriction
   b. YES, but I don’t think I would be able to notice the restriction
      c. YES, but only slightly restrictive
      d. YES, very restrictive

9) I believe that wearing a brace on my ankle would make that ankle feel heavier:
   a. No, not heavier than without a brace
   b. YES, but only slightly heavier
   c. YES, much heavier

10) I believe that wearing an ankle brace would cause my ankle to become painful:
   a. NO, not more painful than without the brace
   b. YES, slight increase in pain
   c. YES, much more painful

11) I believe that discontinuing wearing a brace after wearing a brace for a long period (> 1 month) would make my ankle feel:
   a. Much more stable
   b. Slightly more stable
   c. No change
   d. Slightly less stable
   e. Much less stable

12) Main reason I choose not to wear a brace right now: ________________________
Appendix B: Questionnaire 2

Name: 
Group: 

Please circle the answer that best represents your opinion 
Please only circle 1 answer per question 

1) When running on the court, I felt wearing an ankle brace made me run: 
   a. Much faster 
   b. Slightly faster 
   c. No difference than without the brace 
   d. Slightly slower 
   e. Much slower 

2) I felt wearing an ankle brace made me jump: 
   a. Much higher 
   b. Slightly higher 
   c. No different than without a brace 
   d. Slightly lower 
   e. Much lower 

3) I felt that wearing an ankle brace made me jump: 
   a. Much further 
   b. Slightly further 
   c. No different than without a brace 
   d. Slightly less distance 
   e. Much less distance 

4) When quickly changing directions, I felt wearing an ankle brace made me: 
   a. Much quicker 
   b. Slightly quicker 
   c. No difference than without a brace 
   d. Slightly slower 
   e. Much slower 

5) I felt wearing an ankle brace affected my shooting ability by: 
   a. Greatly increasing my shooting percentage 
   b. Slightly increasing my shooting percentage 
   c. No different than with no brace 
   d. Slightly decreasing my shooting percentage
e. Greatly decreasing my shooting percentage

6) I felt that wearing an ankle brace caused me to:
   a. Fatigue much less quickly
   b. Fatigue slightly less quickly
   c. No difference in fatigue rate when compared to no brace
   d. Fatigue slightly more quickly
   e. Fatigue much more quickly

7) I felt that wearing a brace was:
   a. Much more comfortable than without a brace
   b. Slightly more comfortable than without a brace
   c. No different in comfort than without a brace
   d. Slightly less comfortable than without a brace
   e. Much less comfortable than without a brace

8) I felt that wearing an ankle brace restricted the mobility in my ankle:
   a. NO, no restriction noticed
   c. YES, but only slightly restrictive
   d. YES, very restrictive

9) I felt that wearing a brace on my ankle made that ankle feel heavier:
   a. No, not heavier than without a brace
   b. YES, but only slightly heavier
   c. YES, much heavier

10) On a scale from 0-10 (0 being no pain and 10 being the most pain imaginable):
    a. the pain I feel in my ankle WITHOUT the brace is: _____
    b. the pain I experience in my ankle WHILE wearing the brace is: _____

11) I believe that if I discontinuing wearing this brace after wearing it for a long period (> 1 month) my ankle will feel:
    a. Much more stable
    b. Slightly more stable
    c. No change
    d. Slightly less stable
    e. Much less stable

12) Main reason I choose not to wear a brace right now: ________________________
Appendix C: Questionnaire 3

Name:

Please circle the answer that best represents your opinion
Please only circle 1 answer per question

1) After wearing a brace for 6 weeks, when running on the court, I feel wearing an ankle brace makes me run:
   a. Much faster
   b. Slightly faster
   c. No difference than without the brace
   d. Slightly slower
   e. Much slower

2) After wearing a brace for 6 weeks, I feel wearing an ankle brace makes me jump:
   a. Much higher
   b. Slightly higher
   c. No different than without a brace
   d. Slightly lower
   e. Much lower

3) After wearing a brace for 6 weeks, I feel that wearing an ankle brace makes me jump:
   a. Much further
   b. Slightly further
   c. No different than without a brace
   d. Slightly less distance
   e. Much less distance

4) After wearing a brace for 6 weeks, when quickly changing directions, I feel wearing an ankle brace makes me:
   a. Much quicker
   b. Slightly quicker
   c. No difference than without a brace
   d. Slightly slower
   e. Much slower
5) After wearing a brace for 6 weeks, I feel wearing an ankle brace affects my shooting ability by:
   a. Greatly increasing my shooting percentage
   b. Slightly increasing my shooting percentage
   c. No different than with no brace
   d. Slightly decreasing my shooting percentage
   e. Greatly decreasing my shooting percentage

6) After wearing a brace for 6 weeks, I feel that wearing an ankle brace causes me to:
   a. Fatigue much less quickly
   b. Fatigue slightly less quickly
   c. No difference in fatigue rate when compared to no brace
   d. Fatigue slightly more quickly
   e. Fatigue much more quickly

7) After wearing a brace for 6 weeks, I feel that wearing a brace is:
   a. Much more comfortable than without a brace
   b. Slightly more comfortable than without a brace
   c. No different in comfort than without a brace
   d. Slightly less comfortable than without a brace
   e. Much less comfortable than without a brace

8) After wearing a brace for 6 weeks I feel that wearing an ankle brace restricts the mobility in my ankle:
   a. NO, no restriction noticed
   c. YES, but only slightly restrictive
   d. YES, very restrictive

9) After wearing a brace for 6 weeks, I feel that wearing the brace makes that ankle feel heavier:
   a. No, not heavier than without a brace
   b. YES, but only slightly heavier
   c. YES, much heavier

10) On a scale from 0-10 (0 being no pain and 10 being the most pain imaginable):
    a. the pain I feel in my ankle WITHOUT the brace is: _____
    b. the pain I experience in my ankle WHILE wearing the brace is: _____

11) I believe that if I discontinue wearing this brace (> 1 month) my ankle will feel:
    a. Much more stable while playing
    b. Slightly more stable while playing
    c. No change
    d. Slightly less stable while playing
e. Much less stable while playing

12) **Circle the statement that best represents your current opinion:**
   a. I will continue to wear this brace long term
   
b. I will continue to wear this brace, but only until the season ends (no brace next year)
   c. I will **not** continue to wear this brace, but would consider wearing a brace for a season if I felt my ankle became unstable (e.g. after injury)
   
d. I will **not** continue to wear this brace, but would wear a brace after an injury, until the injury heals
   e. I would NEVER wear this brace
   f. I would NEVER wear this or any other brace

**Main reason:**
______________________________________________________________________________________________
______________________________________________________________________________________________