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Comparison of 3 ankle braces in reducing ankle inversion in a basketball rebounding task

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4 **Highlights**

- 5 • All ankle braces reduced ankle and foot inversion when compared to the unbraced
- 6 condition
- 7 • First study to examine dominant and non-dominant ankle inversion moments
- 8 simultaneously in braced conditions

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115 **10 Abstract** (Word count = 247 words)
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117 **11** Lateral ankle injury incidence rates are very high in the sport of basketball, with a significant
118 **12** proportion occurring during rebounding. Ankle braces are often used as preventative and
119 **13** rehabilitative techniques in hope of minimizing the likelihood of experiencing excessive ankle
120 **14** inversion. This study aims to evaluate the effect of different ankle braces in preventing ankle
121 **15** inversion during a basketball rebounding task.

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126 **16** Sixteen subjects participated in the study (11 males, 5 females; mean age = 26.94 years, SD=5.32;
127 **17** mean height 1.72 m, SD=0.08; mean weight 73.95 kg, SD=13.68).

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130 **18** Participants performed a simulated rebounding task in multiple braced conditions: unbraced
131 **19** (UB), Ossur Formfit (OF), Talarmade Ankleguard Air/Gel Stirrup (TAG) and Bauerfeind
132 **20** Malleoloc (BF). Ankle and foot inversion angles, ankle inversion moments and peroneus longus
133 **21** EMG activity were recorded and analysed to determine the effectiveness of each condition to
134 **22** resist inversion.

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139 **23** All braced conditions reduced ankle and foot inversion angles compared to UB. In the non-
140 **24** dominant limb, OF showed reduced maximum ankle inversion compared to BF (non-dominant
141 **25** mean difference = 0.630°, p<0.001) and reduced foot inversion compared to TAG (non-dominant
142 **26** mean difference = 0.966°, p=0.035). Compared to UB, OF and TAG increased ankle inversion
143 **27** moments in the dominant ankle and showed decreases in the non-dominant ankle. BF reduced
144 **28** mean peak peroneus longus EMG activity compared to all other trials.

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149 **29** Whilst statistically significant differences that were demonstrated between several braced
150 **30** conditions are relatively small, they are clinically significant knowing that the maximum
151 **31** barefoot inversion whilst standing is less than 17 degrees.

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155 **32 Key Words**
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157 **33** Ankle Brace, Inversion, Basketball, Rebounding, Landing
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159
160 **34 Acknowledgments**
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162 **35** I would like to express my gratitude to XXX, for his technical support, to XXX and to XXX and
163 **36** XXX for their assistance throughout the writing process.
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37 **Funding**

38 The research did not receive any funding from agencies in the public, commercial, or not-for-
39 profit sectors.

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227 **41 Introduction**
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229
230 42 Ankle injuries account for approximately 20% of all injuries suffered in sports [1]. The
231 43 likelihood of suffering an ankle sprain is subject to a number of factors, but most notably the
232 44 increased frequency for recurring ankle sprains following a primary injury [2-6]. Financial
233 45 consequences can be significant when considering absence from work and other daily activities.
236 46 Due to the frequent occurrence of ankle sprains and their resulting implications, several
237 47 preventative and rehabilitative measures exist. Among these, the use of prophylactic ankle braces
238 48 is often considered.

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242 49 Several companies produce a variety of models of ankle braces. Models differ in terms of
243 50 material and supportive features, but essentially serve the same purpose of stabilizing the ankle
244 51 joint. The majority of ankle braces are designed to prevent excessive inversion motions, in order
245 52 to protect the wearer from lateral ankle sprains. Such sprains are the most common ankle injury,
246 53 involving damage to the lateral ankle complex due to excessive inversion [2]. Many designs
247 54 involve a low-profile orthosis that can be used in everyday situations since the support fits inside
248 55 most shoes.

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254 56 The ability to provide mechanical support without compromising function is the most important
255 57 factor when considering ankle braces in athletic situations. Several studies have been conducted
256 58 concerning the effects of ankle braces on athletic performance, incidence rate of ankle injuries,
257 59 and lower limb kinematics [7,8]. However, less is known about the effect of ankle braces on
260 60 ankle joint kinematics while performing specific athletic movements.

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263 61 This study aimed to collect kinetic and kinematic data of the ankle during a basketball
264 62 rebounding task. The act of rebounding, or retrieving the ball after a missed shot attempt, is of
265 63 particular interest since nearly half of all basketball-related foot and ankle injuries occur during
266 64 this manoeuvre [3]. Ankle and foot inversion angles as well as electromyography (EMG) activity
267 65 of the peroneus longus was measured to compare the effects of different ankle braces on their
268 66 ability to stabilise the ankle joint complex. Additionally, ground reaction forces were measured
269 67 to analyze the effects of the braces on the ankle inversion moments produced when landing.
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283 **69 Material and Methods**
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286 70 All data were collected at the XXX of the XXX Centre, XXX Hospital and Medical School
287 71 XXX. Ethical permission was granted by the University's School of Medicine Research Ethics
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289 72 Committee prior to data collection.
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291 73 Participants
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294 74 Sixteen participants (eleven male, five female) agreed to take part in this study and were
295 75 recruited by a number of means. Members of the University Women's Basketball Club and
296 76 Mixed Lacrosse Club were invited to participate via email. Recreational basketball players at the
297 77 Institute of Sport and Exercise were also invited to volunteer. In addition, a number of students
300 78 who were completing research projects within the department were encouraged to participate if
301 79 they had experience playing basketball.
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304 80 Participants were required to be within the age range of 18-40 and be physically active. This was
305 81 defined as participating in physical activity, either sport or exercise, at least twice a week. Due to
306 82 the limited funds available to purchase ankle braces, participants were required to have a UK
307 83 shoe size between six and eleven. This ensured that the range of braces acquired would properly
308 84 fit each participant's foot and ankle according to manufacturer guidelines.
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313 85 Experimental protocol
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316 86 Participants attended the gait laboratory for a single testing session. Participants read a
317 87 participant information sheet and completed a written consent form. They were also informed
318 88 about the anonymous and confidential storage of the data collected over the course of the
319 89 research project. Lower-limb dominance was determined by asking which foot participants
322 90 would use to kick a ball. Anthropometric measurements of mass, height, leg length, inter-ASIS
323 91 width, knee-width, and ankle-width were measured and recorded. Ankle circumference was
324 92 measured to assign the appropriate size of ankle brace. A proper fitting VivoBarefoot Evo Pure
325 93 shoe was worn by all participants due to its thin sole and short quarter piece. The same model of
326 94 shoe was used to minimize inconsistencies in testing. Twenty-four retro-reflective markers were
327 95 fixed to the participant, according to a 24-marker foot-inversion model, using double-sided
328 96 adhesive tape. The peroneus longus muscle belly was identified and marked by asking the
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339 97 participant to plantarflex and evert their foot. The skin on the identified area was shaved and
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341 98 treated using NuPrep gel to improve electrical conduction. EMG sensors were fixed on each
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343 99 peroneus longus muscle belly using the Delsys Trigno™ Sensor Skin Interface (SC-F03) and
344 100 further secured using adhesive medical tape.

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347 101 3D motion analysis and ground reaction forces were captured using a fourteen-camera Vicon
348 102 Nexus Motion Capture system (Vicon Motion Systems Ltd., Oxford, UK) operated at 200 Hz.
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350 103 EMG activity was captured through a Delsys Trigno™ Wireless System (Delsys Inc.,
351 104 Massachusetts, USA). Data were collected simultaneously through the Vicon software using a
352 105 desktop computer.

354
355 106 Using a block-randomization process, participants were assigned the order in which they were to
356 107 complete the four conditions: Talarmade Ankleguard Air/Gel Stirrup (TAG) (Figure 1), Ossur
357 108 Formfit (OF) (Figure 2), Bauerfeind Malleoloc (BF) (Figure 3), and unbraced (UB). Ankle width
358 109 was measured prior to the beginning of testing each condition to accompany the changes in
360 110 width of the different braces.

363 364 111 Rebounding apparatus

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367 112 The apparatus was designed and built within the department. The basketball was suspended from
368 113 the device's lowest point using Velcro. The height at which the ball rested was adjustable to
369 114 accommodate participants of different heights and jumping capabilities (Figure 4).

371 372 373 115 Rebounding task

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375 116 Participants performed their regular exercise or sporting warm-up routine and were familiarized
376 117 with the rebounding task prior to data collection. The ball was set to a height that required the
377 118 participant to jump in order to retrieve it, but remained attainable over a minimum of 20 trials.
378 119 During the rebounding task, participants began with each of their feet on its respective plate, at a
380 120 width they would use naturally to jump. When signalled, participants would jump vertically,
381 121 securing the basketball, and land back down on the force plates (Figure 4). Both feet were
382 122 required to land completely on their respective force plates in order for the trial to be deemed
383 123 successful. The rebounding task was performed under the four conditions and was repeated until
384 124 five successful trials were obtained for each condition.

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395 125 Data analysis
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398 126 Using Vicon Nexus software, a 3D representation of each trial was formulated by manually
399 127 marking all the reflective markers and running a custom foot inversion Pipeline. Gaps in the
400
401 128 data were filled using the appropriate gap filling techniques.
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404 129 Data from the whole trial were used when considering the maximum ankle and foot inversion
405 130 angles. However, when observing maximum ankle inversion moments and EMG activity of the
406 131 peroneus longus, only data from the landing portion of the trial were considered. There were two
408 132 reasons for this. The first reason was that there were no ground reaction forces present while the
409 133 participant was in the air, therefore joint moments could not be calculated. Secondly, in each trial
410 134 the peroneus longus had two spikes in EMG activity: while jumping, and while landing. The
411 135 spike in activity due to the jump, if included in analysis, could alter the interpretation of how the
412 136 braces affected peroneus longus activity, and thus how the ankle and foot are stabilized during
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416 137 the landing portion.
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419 138 Statistical Analysis
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421 139 Data were analysed using IBM SPSS Version 22. The General Linear Model was used to
422 140 calculate mean estimates of the four conditions, followed by pairwise comparisons to define any
423 141 significant differences between these conditions. A p-value of 0.05 was used to establish
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425 142 statistical significance.
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429 143 **Results**
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431 144 A total of 16 participants completed the study. For quality purposes, data from 15 participants
432 145 was included for calculations involving maximum ankle and foot inversion angles as well as
433 146 ankle inversion moments, whilst data from 14 participants was used for analysis of EMG activity
434 147 of the peroneus longus. Regarding ankle and foot inversion angles as well as ankle inversion
435 148 moments, data from one participant was excluded due to excessive gaps in Vicon data.
436 149 Regarding EMG, data was excluded from two participants due to technical difficulties with the
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Table 1: Sample means for maximum ankle and foot inversion angles, maximum ankle inversion moments, mean peak EMG activity of peroneus longus and peak value EMG activity of peroneus longus for unbraced (UB), Ossur Formfit (OF), Talar made Ankleguard (TAG) and Bauerfeind Malleoloc (BM) trials. Values are presented as sample mean ± standard deviation for the dominant (D) and non-dominant (ND) limbs

	Maximum ankle inversion (degrees)		Maximum foot inversion (degrees)		Maximum ankle inversion moments (Nm/kg)		Mean peak EMG activity of peroneus longus (mV)		Peak EMG activity of peroneus longus (mV)	
	D	ND	D	ND	D	ND	D	ND	D	ND
UB	5.719	6.568	7.422	7.048	0.283	0.359	0.0354	0.0555	0.0982	0.0795
	±	±	±	±	±	±	±	±	±	±
	3.984	5.131	3.229	3.237	0.200	0.259	0.0192	0.0285	0.0394	0.0270
OF	4.012	4.315	5.669	4.086	0.331	0.303	0.0320	0.0554	0.0931	0.0874
	±	±	±	±	±	±	±	±	±	±
	2.865	3.929	2.885	2.733	0.317	0.195	0.0171	0.0344	0.0352	0.0504
TAG	4.147	4.501	6.558	5.052	0.322	0.322	0.0366	0.0558	0.1046	0.0790
	±	±	±	±	±	±	±	±	±	±
	3.195	4.489	2.898	2.859	0.278	0.204	0.0333	0.0286	0.0914	0.0241
BF	4.198	4.945	5.675	4.428	0.291	0.310	0.0275	0.0463	0.0929	0.0846
	±	±	±	±	±	±	±	±	±	±
	2.970	4.621	1.811	2.480	0.237	0.213	0.0142	0.0260	0.0380	0.0604

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157 **Table 2: Pairwise comparisons between unbraced (UB), Ossur Formfit (OF), Talarmade Ankleguard (TAG) and Bauerfeind**
158 **Malleoloc (BM) in the dominant limb**

PARAMETER	I	J	MEAN DIFFERENCE (I-J)	STD. ERROR	P- VALUE
MAXIMUM ANKLE INVERSION (°)	UB	OF	1.715*	.173	.000
		TAG	1.627*	.590	.007
		BF	1.509*	.155	.000
	OF	UB	-1.715*	.173	.000
		TAG	-0.088	.478	.855
		BF	-0.206*	.100	.043
	TAG	UB	-1.627*	.590	.007
		OF	0.088	.478	.855
		BF	-0.118	.504	.816
	BF	UB	-1.509*	.155	.000
		OF	0.206*	.100	.043
		TAG	0.118	.504	.816
MAXIMUM ANKLE INVERSION MOMENT (NM/KG)	UB	OF	-0.048*	0.018	.011
		TAG	-0.039*	0.015	.011
		BF	-0.008	0.040	.839
	OF	UB	0.048*	0.018	.011
		TAG	0.009	0.014	.511
		BF	0.040	0.049	.419
	TAG	UB	0.039*	0.015	.011
		OF	-0.009	0.014	.511
		BF	0.031	0.047	.509
	BF	UB	0.008	0.040	.839
		OF	-0.040	0.049	.419
		TAG	-0.031	0.047	.509
MAXIMUM FOOT INVERSION (°)	UB	OF	1.732*	.416	.000
		TAG	0.894	.523	.093
		BF	1.738*	.438	.000
	OF	UB	-1.732*	.416	.000
		TAG	-0.838	.489	.093
		BF	0.006	.327	.985
	TAG	UB	-0.894	.523	.093
		OF	0.838	.489	.093
		BF	0.844*	.381	.031
	BF	UB	-1.738*	.438	.000
		OF	-0.006	.327	.985
		TAG	-0.844*	.381	.031
MEAN PEAK PERONEUS LONGUS EMG ACTIVITY (MV)	UB	OF	0.003	.002	.131
		TAG	-0.001	.004	.791
		BF	0.008*	.002	.002
	OF	UB	-0.003	.002	.131
		TAG	-0.005	.005	.317
		BF	0.004	.002	.074
	TAG	UB	0.001	.004	.791
		OF	0.005	.005	.317
		BF	0.009*	.004	.033
	BF	UB	-0.008*	.002	.002
		OF	-0.004	.002	.074
		TAG	-0.009*	.004	.033
PEAK VALUE PERONEUS LONGUS ACTIVITY (MV)	UB	OF	0.005	.006	.395
		TAG	-0.007	.011	.569
		BF	0.005	.006	.362
	OF	UB	-0.005	.006	.395
		TAG	-0.012	.012	.327
		BF	0.000	.005	.970
	TAG	UB	0.007	.011	.569
		OF	0.012	.012	.327
		BF	0.012	.010	.245
	BF	UB	-0.005	.006	.362
		OF	0.000	.005	.970
		TAG	-0.012	.010	.245

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160 **Table 3: Pairwise comparisons between unbraced (UB), Ossur Formfit (OF), Talarmade Ankleguard (TAG) and Bauerfeind**
161 **Malleoloc (BM) the non-dominant limb**

PARAMETER	I	J	MEAN DIFFERENCE (I-J)	STD. ERROR	P-VALUE
MAXIMUM ANKLE INVERSION (°)	UB	OF	2.275*	.187	.000
		TAG	2.317*	.944	.017
		BF	1.636*	.140	.000
	OF	UB	-2.275*	.187	.000
		TAG	0.041	.810	.959
		BF	-0.640*	.141	.000
	TAG	UB	-2.317*	.944	.017
		OF	-0.041	.810	.959
		BF	-0.681	.862	.432
	BF	UB	-1.636*	.140	.000
		OF	0.640*	.141	.000
		TAG	0.681	.862	.432
MAXIMUM ANKLE INVERSION MOMENT (NM/KG)	UB	OF	0.056*	.018	.003
		TAG	0.037	.020	.066
		BF	0.049	.046	.294
	OF	UB	-0.056*	.018	.003
		TAG	-0.019	.013	.151
		BF	-0.007	.038	.853
	TAG	UB	-0.037	.020	.066
		OF	0.019	.013	.151
		BF	0.012	.039	.764
	BF	UB	-0.049	.046	.294
		OF	0.007	.038	.853
		TAG	-0.012	.039	.764
MAXIMUM FOOT INVERSION (°)	UB	OF	3.031*	.516	.000
		TAG	1.996*	.552	.001
		BF	2.599*	.554	.000
	OF	UB	-3.031*	.516	.000
		TAG	-1.034*	.387	.010
		BF	-0.432	.335	.203
	TAG	UB	-1.996*	.552	.001
		OF	1.034*	.387	.010
		BF	0.602	.367	.107
	BF	UB	-2.599*	.554	.000
		OF	0.432	.335	.203
		TAG	-0.602	.367	.107
MEAN PEAK PERONEUS LONGUS EMG ACTIVITY (MV)	UB	OF	5.848E-5	.005	.990
		TAG	0.000	.004	.927
		BF	0.009*	.004	.032
	OF	UB	-5.848E-5	.005	.990
		TAG	0.000	.005	.930
		BF	0.009	.005	.075
	TAG	UB	0.000	.004	.927
		OF	0.000	.005	.930
		BF	0.010*	.004	.023
	BF	UB	-0.009*	.004	.032
		OF	-0.009	.005	.075
		TAG	-0.010*	.004	.023
PEAK VALUE PERONEUS LONGUS ACTIVITY (MV)	UB	OF	-0.008	.007	.268
		TAG	0.000	.004	.912
		BF	-0.005	.008	.547
	OF	UB	0.008	.007	.268
		TAG	0.008	.006	.191
		BF	0.003	.009	.752
	TAG	UB	0.000	.004	.912
		OF	-0.008	.006	.191
		BF	-0.006	.007	.426
	BF	UB	0.005	.008	.547
		OF	-0.003	.009	.752
		TAG	0.006	.007	.426

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619 **164 Discussion**

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622 **165 Maximum ankle inversion angles**

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624 **166** When compared to UB in the dominant side, OF, TAG and BF reduced ankle inversion by
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626 **167** 1.707° ($p < 0.001$), 1.572° ($p = 0.009$) and 1.521° ($p < 0.001$), respectively. Although there were
627
628 **168** no significant differences between braces conditions, OF showed a reduction of 0.186° ($p =$
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630 **169** 0.067) when compared to BF.

631
632 **170** Similarly to the dominant leg, all braced conditions reduced ankle inversion when compared to
633
634 **171** UB. OF, TAG, and BF significantly reduced ankle inversion by 2.252° ($p < 0.001$), 2.067° ($p =$
635
636 **172** 0.035) and 1.623° ($p < 0.001$) respectively. Additionally, OF reduced ankle inversion by 0.630°
637
638 **173** ($p < 0.001$) when compared to BF.

639 **174** Whilst the present study suggests all braced conditions reduced ankle inversion when compared
640
641 **175** to the control group, only semi-rigid braces reduced ankle inversion during forced inversion
642
643 **176** trials, whilst lace-up braces showed no significant differences from the control group [7].

644 **177** Similarly, less ankle inversion has been observed in semi-rigid ankle braces than in lace-up ankle
645
646 **178** braces while performing a change-of-direction manoeuvre [8]. Considering these two studies and
647
648 **179** the present results, it may be suggested that differences arise due to the nature of the task, thus
649
650 **180** the degree of protection provided by specific braces against ankle inversion may be dependent on
651
652 **181** the activities being performed.

653 **182 Maximum foot inversion angles**

654
655 **183** When compared to UB, OF and BF significantly reduced the maximum foot inversion angle in the
656
657 **184** dominant foot by 1.753° ($p < 0.001$) and 1.747° ($p < 0.001$). TAG also appeared to reduce foot
658
659 **185** inversion by 0.864° ($p = 0.093$) when compared to UB but did not reach statistical significance.

660 **186** When compared to TAG, BF significantly reduced the foot inversion angle by 0.0884° ($p = 0.020$),
661
662 **187** while OF showed a reduction of 0.889° ($p = 0.066$) nearly reaching statistical significance.

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664 **188** All braced conditions reduced maximum foot inversion in the non-dominant leg when compared
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666 **189** to UB. OF, TAG, and BF decreased the maximum foot inversion angle by 2.962° ($p < 0.001$),
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668 **190** 1.996° ($p < 0.001$) and 2.620° ($p < 0.001$), respectively. When considering TAG, OF significantly

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675 191 reduced the maximum foot inversion by 0.966° ($p = 0.012$) while the reduction seen by BF is on
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677 192 the cusp of statistical significance (0.624° , $p = 0.079$). Despite attaining statistically significant
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679 193 differences in ankle and foot inversion angles between trials, the clinical significance of these
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681 194 findings may be disputed. However, as maximum standing foot inversion angle is less than 17° , a
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683 195 reduction of 1° would yield a relative decrease of nearly 6% and therefore must be considered
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685 196 clinically significant [9, 10].

686 197 The loading required to cause an injury changes with different positions of the foot [11]. Being
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688 198 able to control, or maintain awareness of, the position of the foot whilst in the air may play a role
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690 199 in preventing foot and ankle injuries.

691 200 The reduction in foot inversion seen in the present study may be influenced by the design of the
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693 201 ankle braces. TAG possesses only two straps to secure the medial and lateral stirrups to each other.
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695 202 The straps wrap around the leg, perpendicularly to the long axis of the brace, and are fastened
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697 203 using Velcro. They do not at any point cross over each other. OF and BF use straps that cross each
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699 204 other on the anterior portion of the shank. Furthermore, the OF and BF are more securely
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701 205 positioned under the heel. This, in combination with the crossing of straps may provide additional
702
703 206 support, and/or keep the stirrups of the braces in better positions to resist inversion motions.

704 207 Maximum ankle inversion moments

705 208 When compared to UB, OF and TAG showed a significant increase in the maximum ankle
706
707 209 inversion moment in the dominant ankle by 0.048 Nm/kg ($p = 0.011$) and 0.039 Nm/kg ($p = 0.011$),
708
709 210 respectively. No significant differences existed between the braces.

711 211 In the non-dominant ankle, when compared to UB only OF showed a significant difference in
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713 212 reducing the maximum ankle inversion moment by 0.056 Nm/kg ($p = 0.003$). TAG also showed
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715 213 evidence of decreasing the maximum ankle moment by 0.037 Nm/kg ($p = 0.066$), but does not
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717 214 quite reach statistical significance. No significant differences existed between braced conditions.

718 215 When compared to UB, the increases on the dominant side and decreases on the non-dominant
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720 216 side suggest that participants relied more heavily on their dominant limb to perform the task in
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722 217 braced conditions. Some studies have shown that athletes tend to favour their dominant side for

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731 218 jumping, kicking and landing [12,13]. However, these studies did not observe the effects of braces
732 219 on lower limb kinetics.

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735 220 Mean peak EMG value of peroneus longus during landing

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737 221 When compared to BF, both UB and TAG demonstrated significant increases in mean peak EMG
738 222 value in the dominant leg, with increases of 0.0079 mV ($p = 0.002$) and 0.0091 ($p = 0.033$),
740 223 respectively. OF reports a slight increase of 0.0045 mV ($p = 0.074$), narrowly missing statistical
742 224 significance.

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744 225 Similar results were seen in the non-dominant leg. When compared to BF, both UB and TAG
745 226 demonstrated significant increases in mean peak EMG value, with increases of 0.0092 mV ($p =$
747 227 0.032) and 0.0095 ($p = 0.023$), respectively. OF displayed an increase of 0.0091 mV ($p = 0.075$)
749 228 and nearly reached statistical significance.

750
751 229 The reduction in peroneus longus activity displayed by BF can be interpreted in two ways. The
752 230 first interpretation suggests that the brace is providing mechanical support, and resisting inversion,
754 231 therefore the peroneus longus, being the primary evertor of the foot, does not have to activate so
756 232 intensely. The second idea proposes that the external support actually inhibits the muscle, and may
758 233 in fact pose an increased risk of ankle inversion injury to the wearer [14]. It is unclear as to whether
759 234 this phenomenon holds, since both OF and TAG decrease inversion of the foot and ankle compared
761 235 to UB. Therefore, a reduction in inversion is not necessarily associated with decreases in peroneus
763 236 longus muscle activity.

764
765 237 In a study examining change of direction manoeuvres, no significant differences in mean peroneus
766 238 longus activity were noted between braced and unbraced trials [15]. This inconsistency in results
768 239 may be explained by the different tasks performed or the types of braces worn.

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771 240 Peak EMG value of peroneus longus during landing

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773 241 No significant differences were found concerning peak EMG activity between any of the
774 242 conditions. The similar peak EMG readings between conditions may be explained by the repetitive
775 243 motion of retrieving the ball from a consistent height. Similar consistencies have been found in
777 244 other studies which involve performing an athletic task repeatedly. No significant differences in
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788 245 peak peroneus longus activity were observed while performing change of direction manoeuvres in
789 246 braced and unbraced conditions [15], nor between semi-rigid and lace-up braces [14].
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791 247 However, the latter study did report a decrease in EMG activity in the braced conditions when
792 248 compared to the unbraced trials [14]. This raises concerns as to how differences in experimental
793 249 procedures and protocols may yield different results, despite relative similarities. Therefore,
796 250 further studies should be conducted in an attempt to more accurately describe the effects of ankle
797 251 bracing on peak EMG activity of the peroneus longus during athletic trials.
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800 252 Limitations
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803 253 Due to the relatively small sample size, nearly statistically significant values were mentioned
804 254 several times in the discussion section. These were mentioned when statistically significant
805 255 differences were noted in the opposing limb in the conditions being considered. Further studies
806 256 should include larger sample sizes to observe whether these differences would reach statistical
807 257 significance with more participants.
810

811 258 It is important to consider that data were not collected during an actual basketball game. The task
812 259 that was performed allowed for safe and successful completion. Therefore, the simulated
813 260 rebounding task did not include many of the factors that may contribute to lateral ankle injuries
814 261 sustained during a match.
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819 262 Consistencies in peroneus longus activity may be explained by the lack of horizontal movement
820 263 and the consistent height of the basketball during trials. Adding lateral movement to a similar
821 264 study, as well as varying the height of the suspended basketball, may provide more realistic
822 265 interpretations as to how ankle braces affect peroneus longus activity during game situations.
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826 266 Variability within the data may be due to the array of athletic profiles possessed by participants.
827 267 Both the type of sport, as well as the level of competition, could influence the results. In order to
828 268 improve this, recruitment could involve a specific core of athletes who compete at the same level.
829 269 However, the range of athletic profiles allowed for more general consensus concerning the
830 270 effectiveness of the braces in reducing ankle inversion.
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272 Future considerations

273 The aim of this study was to evaluate the effects of different ankle braces on resisting ankle
274 inversion in a basketball rebounding task. However, no inter-limb differences were analyzed
275 within each condition. In braced conditions, the increased ankle inversion moments on the
276 dominant side and decreases on the non-dominant side suggest that there are some changes in
277 landing kinematics versus those observed in the unbraced condition. Future studies should consider
278 investigating EMG activity of other lower limb muscles involved in jumping and landing in order
279 to understand better how forces are distributed while wearing braces bilaterally.

280 Pressure platforms or insoles could be used while performing a rebounding task to further
281 understanding of how weight distribution is affected while wearing ankle braces. Pressure
282 distribution in combination with other kinetic and kinematic data would provide valuable
283 information regarding how the ankle and foot behave during jumping and landing. Additionally,
284 pressure sensors within the shoe/ankle braces would provide information concerning the proper
285 fitting of braces.

286 In addition to peak EMG values, the time required to reach this maximum should be considered.
287 People suffering from chronic ankle instability demonstrate slower eversion reaction times [16].
288 Perhaps more can be learned from the time required to reach peak peroneus longus activity, rather
289 than the magnitude of the peak itself.

290 Furthermore, to better understand how the braces affect ankle and foot inversion throughout the
291 course of the trial, future studies should investigate these values at specific points in the rebounding
292 task. These could include, for example, inversion angles at maximum loading, the instant prior to
293 landing and on landing as these may be when ankle sprains occur with varying footwear
294 configurations [17].

295 **Conclusion**

296 There is an overall agreement throughout the literature that wearing ankle braces provides
297 protection against ankle inversion injuries, likely through the increased mechanical support they
298 provide. However, the effect of ankle braces on peroneus longus activity is not consistent
299 throughout the literature and needs to be further explored.

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899 300 This research study aimed to investigate the effect of wearing different ankle braces in reducing
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901 301 ankle inversion, specifically in a basketball rebounding task. By examining the inversion angles
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903 302 of the foot and ankle, the inversion moments of the ankle joint, and the muscle activity of the
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905 303 primary evertor of the foot, a general idea can be conceived regarding how ankle braces protect
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907 304 the foot during this precise task.

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909 305 All braces reduced ankle and foot inversion when compared to the unbraced condition. The lace-
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911 306 up brace (Ossur Formfit) reduced ankle inversion compared to one semi-rigid brace (Bauerfeind
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913 307 Malleoloc), and also reduced foot inversion when compared to the second semi-rigid brace
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915 308 (Talarmade Airguard Air/Gel Stirrup). Bauerfeind Malleoloc reported lower mean peak EMG in
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917 309 the peroneus longus compared to all other conditions. However, no peak value EMG differences
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919 310 were noted between any of the conditions.

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921 311 Of the ankle braces examined, the Ossur Formfit seems to be the most efficient ankle brace overall
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923 312 in preventing ankle inversion during the rebounding task. This was demonstrated by its ability to
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925 313 restrict ankle and foot inversion better than the Bauerfeind Malleoloc and Talarmade Ankleguard
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927 314 Air/Gel Stirrup, respectively. Since rebounding is one of many actions performed during
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929 315 basketball, research using these same braces in different basketball manoeuvres should be
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931 316 conducted to deduce which brace offers the best overall protection. This would in turn would help
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933 317 clinicians and athletic coaches provide reliable recommendations thus reducing the risk of ankle
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935 318 injury.

932 319 **Brief Summary**

934 320 What is known

- 937 321 • There is a general consensus in the literature that semi-rigid and lace-up ankle braces are
938
939 322 effective in preventing ankle inversion.

- 941 323 • Semi-rigid braces are more efficient in reducing ankle inversion in change of direction
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943 324 manoeuvres, however less is known about how the braces perform in the array of tasks
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945 325 performed during an actual basketball game.

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327 What this study adds

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- The results suggest that lace-up ankle braces are the most effective design of brace in resisting ankle inversion in a basketball rebounding task, as seen in the reduction of ankle and foot inversion when compared to the semi-rigid braces.
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- Peak peroneus longus activity is not affected by wearing ankle braces during the landing portion of the trial.
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- There is some evidence that semi-rigid ankle braces reduce mean peak peroneus longus activity during the landing portion of the trial.
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1123	382	Figure captions
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1126	383	Figure 1 Talarmade Ankleguard Air/Gel Stirrup
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1128	384	Figure 2 Ossur Formfit
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1131	385	Figure 3 Bauerfeind Malleoloc
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1133	386	Figure 4 Rebounding task
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