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4 Influence of a full body compression suit on trunk positioning and knee joint mechanics
5 during lateral movements.

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21 **Running Title:** Full body compression suit and lateral movements.

22

23 **Abstract**

24 Trunk positioning has been shown to be associated with knee joint loading during athletic tasks,
25 especially changes of direction. The purpose of the present study was to test whether a full body
26 compression suit (FBCS) would improve trunk positioning and knee joint control during lateral
27 movements. Twelve female athletes performed lateral reactive jumps (LRJ) and unanticipated
28 cuttings with and without the customized FBCS, while 3D kinematics and kinetics were
29 measured. FBCS did not influence trunk positioning during LRJ and led to increased trunk
30 lateral lean during cuttings ($P < .001$). However, while wearing FBCS, knee joint abduction
31 and internal rotation angles were reduced during LRJ ($P < .001$ and $P = .013$, respectively),
32 whereas knee joint moments were comparable during cuttings. FBCS cannot support the trunk
33 segment during unanticipated dynamic movements. But increased trunk lateral lean during
34 cutting maneuvers was not high enough to elicit increased knee joint moments. On the contrary,
35 knee joint abduction and internal rotation were reduced during LRJ, speaking for a better knee
36 joint alignment with FBCS. Athletes seeking to improve trunk positioning may not benefit from
37 a full body compression suit.

38

39 **Keywords:** cuttings, perturbation, trunk lateral lean, knee abduction moment, agility.

40

41 **Word Count:** 3995 words

42

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Introduction

44 Lateral movements with changes of direction are common in many team sports such as
45 soccer or handball. During cutting maneuvers, the athlete performs a complex dynamic task by
46 quickly changing their direction of movement while securing their balance. Knee joint control
47 is an essential requirement during such movements to prevent misalignments in the lower
48 extremities with the consequence that the knee may be injured.^{1,2} Non-contact anterior cruciate
49 ligament (ACL) injury mechanism during cutting maneuvers typically involves knee external
50 flexion moment combined with dynamic valgus rotation with the body weight shifted over the
51 injured leg.² Trunk positioning during lateral movements is of interest as it would influence the
52 location of the body weight, and potential knee joint loads.^{3,4} Hewett and Myer³ proposed a
53 knee injury model that accounted for both the trunk and hip joints, because increased trunk
54 lateral lean is reportedly associated with larger external knee abduction moments. Greater
55 lateral trunk position has been shown during anterior cruciate ligament injury situations in
56 female athletes.⁵ Different laboratory studies using cutting maneuvers and lateral reactive jumps
57 paradigms have demonstrated that increased trunk lateral lean is positively associated with
58 increased knee abduction moments.⁶⁻⁸ Further, increased knee joint loading has been associated
59 with increased trunk rotation away from the stance limb.^{8,9} For instance, higher knee internal
60 rotation moment was found for trunk rotation in the opposite direction to the cutting maneuver.⁸
61 Accordingly, any improvement of trunk positioning is of interest with regard to knee joint
62 loading. This would be especially true for female athletes, whose incidence of ACL injuries in
63 sports such as soccer and basketball is much higher than male athletes.^{10,11}

64 In sport sciences, the influence of compression garments, providing passive support to
65 different body segments during exercise has been extensively studied.¹² It has been showed that
66 compressive and elastic garments could reduce the range of motion of the joint.^{13,14}
67 Compression shorts reduced the active range of motion during hip flexion in a non-athletic

68 task¹³ and hip range of motion during a 60 m sprint.¹⁴ Wearing shorts with directional
69 compression was associated with reduced hip adductor activity during cutting manoeuvres.¹⁵ In
70 this latter study, the use of diagonal bands of fabric that only stretch along their length increased
71 the compression level along the line of action of hip adductors. Therefore, apparel, through their
72 compression and elasticity properties, could be used to passively support body segments and
73 joints during various tasks. A compression suit that would functionally support the trunk over
74 the pelvis and leg could be a solution to avoid trunk positioning in the opposite direction to the
75 intended movement. Such apparel would work as external trunk stabilizers to improve trunk
76 positioning during various tasks, especially lateral movements, and subsequently possibly
77 reduce knee joint loading.

78 In sports, any improvement of movement control would further be relevant if associated
79 with enhanced performance. However, when considering whole-body dynamic tasks, wearing
80 a compression suit did not influence performance in cricket players¹⁶ or endurance performance
81 during running.¹⁷ Only one study has shown possible benefits of a whole-body compression
82 garment on performance during high intensity intermittent exercises, mainly because of better
83 muscle oxygenation.¹⁸ Therefore, athletic performance is not likely to be increased when using
84 garments.

85 The aim of this present study was to test whether compression garments can improve
86 trunk and hip positioning and resultant knee joint loading, while not decreasing performance
87 during dynamic lateral sporting movements. For that purpose, a full body compression suit with
88 functional elastic straps was designed to improve trunk positioning and knee joint control
89 during lateral movements. We tested the hypotheses that i) trunk and hip joint angles would be
90 reduced with the compression suit, ii) knee joint abduction moment would be reduced with the
91 compression suit and iii) exercise performance level would be maintained while wearing the
92 compression suit.

93

Methods

94 According to other studies evaluating comparable dependent measures during
95 unanticipated lateral movements¹⁹ or the influence of compression shorts on sports
96 performance,¹³ a sample size of 13 participants was estimated relevant for statistical analysis.
97 The rationale for focusing on females was their relative higher risk of sustaining non-contact
98 ACL injuries.¹⁰ Among the 13 female athletes recruited to participate to the study, one was
99 injured during a training session with her team during the investigation period and could not
100 take part in the measurements. Therefore, 12 female athletes (body height = 171 ± 4 cm; body
101 mass = 59 ± 4 kg; age = 22 ± 2 years) who were familiar with lateral movements (soccer,
102 basketball and handball) completed the entire study. Participants did not have a previous history
103 of serious knee injury or any current knee pain. Written consent was obtained prior to study
104 participation. The study was approved by the local ethics committee (approval 72/14) and was
105 conformed to requirements stipulated in the Declaration of Helsinki.

106 During a first visit, participants' body dimensions were scanned (BodyKinectizer,
107 adidas IT Innovation, Herzogenaurach, Germany), in order to customize the full body
108 compression suit. During a second visit at our laboratory, participants performed different
109 lateral movements and performance tests under two different apparel conditions, either while
110 wearing the customized full body compression suit (FBCS) with 2x thermoplastic polyurethane
111 (TPU) layers or with standard sport shorts and bras (Control). FBCS was a prototype specially
112 designed for the present study in order to provide support for the trunk over the pelvis segment
113 in three dimensions. For that purpose, a mean compression level of 5.2 mmHg was achieved
114 and the 2x TPU layers design linked the upper body with lower limbs across the pelvis in the
115 back (Figure 1). The compression level was first determined for elastic and TPU fabrics
116 separately, according to their relative stretch and then averaged over the whole suit. At specific
117 points, the compression level was even greater, for instance at the low waist and thigh lines (8.3

118 and 6.7 mmHg, respectively). By determining the compression exactly and creating a
119 customized suit for each subject, identical apparel conditions were guaranteed for all subjects,
120 and the possible effectiveness of the compressive suit was measurable.²⁰ To determine to what
121 extent wearing FBCS would influence trunk range of motion, trunk passive flexibility in frontal
122 and sagittal planes was measured according to the literature.²¹ In addition, trunk rotation passive
123 flexibility was evaluated while participants lay on their backs with the right bent knee crossing
124 over the thigh of the left extended leg. Participants remained relaxed and kept their back and
125 both shoulders in contact with the floor, while the distance between the floor and knee was
126 measured. Reduced mean trunk passive flexibility over all participants was obtained with FBCS
127 compared to Control for flexion (2.2 cm) and rotation (2 cm), but was comparable for lateral
128 flexion.

129 The two conditions were randomly assigned over all participants. According to pilot
130 measurements, participants were given 30 minutes to become accustomed to the suit. During
131 this period, standardized exercises were carried out based on runs, jumps and cuttings. When
132 subjects started the measurement with FBCS, another 30 minutes practice was given to them
133 prior to the Control condition.

134 Firstly, participants performed perturbed lateral reactive jumps (LRJ) to focus on the
135 influence of FBCS on movement control during a functional task associated with high trunk
136 lateral lean in the frontal plane. From a standing position, subjects performed a lateral reactive
137 movement by jumping to their left side and then pushing off with their left leg to get back to
138 their original position. Jump distance was set at 124% of the individual leg length. In order to
139 induce lateral perturbations, subjects performed LRJ on a motor-driven plate, which could
140 translate in the horizontal (medio-lateral) direction. The specially designed motor-driven plate
141 (University of Sport Science, Freiburg, Germany) constituted of two independently moving
142 plates (1.15 m x 0.3 m), each driven by a separate motor (AKM51G, Danaher Motion,

143 Düsseldorf, Germany). Details of this material have been previously described in the
144 literature.²² LRJ were performed, either without any perturbation (stable condition), or with a
145 perturbation to the left (sliding condition) or to the right (counteracting condition) as soon as
146 the foot made initial contact with the plate. Each perturbation consisted of a 10 cm translation
147 in either direction over 250 ms, inducing a peak velocity of $0.55 \text{ m}\cdot\text{s}^{-1}$ after 120 ms.
148 Unpredictability was introduced using these three different landing modalities (stable, sliding,
149 counteracting) that were unknown prior to movement execution. Perturbation was triggered by
150 breaking a light beam (M18 series, Panasonic Electric Works Europe AG, Holzkirchen,
151 Germany), 0.04 m above the plate, to compensate for the delay in activation of the motor-driven
152 plate.

153 Secondly, participants were asked to perform either cutting maneuvers to 45° ,
154 crossovers to -20° or straight runs on a force plate (BP600900, AMTI®, Watertown, USA),
155 after approaching the force plate (FP) at $4 \pm 0.2 \text{ m}\cdot\text{s}^{-1}$. The direction of the movement was
156 indicated in a randomized order by a light signal occurring 650 ms before the left foot contacted
157 the FP. The visual light stimulus was triggered automatically during the approach run via a light
158 switch (M18 series, Panasonic Electric Works Europe AG, Holzkirchen, Germany) placed 3.7
159 m from FP. According to a light cue delay set individually, the 650 ms time could be achieved.
160 The three lights were placed at eye level in the directions of the three tasks, 7 m away from the
161 FP. The 45° cutting maneuver to the right was the only movement to be further analyzed due
162 to its relevance when investigating performance and injury aspects of changing direction tasks.

163 Finally, three different performance tests were conducted to evaluate agility with the 5-
164 10-5 yards test, jump height, i.e. leg muscle power, with counter movement jumps (CMJ) and
165 core strength with a cable lift test. This latter test targets the action of hips, torso rotators, upper
166 back, chest and shoulders while turning the trunk away from the strength machine as the hands
167 first pull the rope cable handle towards the chest and then push up and away. The rationale for

168 these tests is the importance of agility, leg muscle power and core strength for high performance
169 during soccer, basketball or handball games. The good reliability of jump height measurements
170 during CMJ has been reported in the literature (intraclass correlation coefficient (ICC) = 0.9),²³
171 as well as for the 5-10-5 yards agility test (ICC > 0.87).²⁴ The time to accomplish the agility
172 test was measured manually. Two CMJ were performed on the FP. The cable lift test was
173 conducted twice at 70% of one-repetition maximum.

174 All participants were familiar with such movements due to their sport practice and were
175 given enough practice trials to feel comfortable with all task modalities prior to the
176 measurements.

177 Three-dimensional leg kinematics were recorded using reflective skin markers (\varnothing 14
178 mm) placed on anatomical landmarks of the subjects' trunk (three markers), pelvis (four
179 markers) and left thigh (three markers), shank (four markers) and foot (six markers). Markers
180 were captured with a 12-camera motion analysis system (Vicon MXTM, VICON Motion
181 Systems Ltd.®, Oxford, UK) with a sampling frequency of 200 Hz. A static trial with the
182 subject standing in a pre-defined neutral position was used to define the kinematic model and
183 to calculate segment lengths and joint centers. The kinematic modelling was performed with
184 the motion analysis software (Vicon Nexus 1.6.1, VICON Motion Systems Ltd.®, Oxford,
185 UK). Joint kinematics in three rotational degrees of freedom were determined using an yxz
186 Euler rotation sequence of the respective segment coordinate system according to the global
187 reference system defined in Vicon. This rotation sequence was around the flexion/extension
188 axis first, then around the abduction/adduction axis followed by the rotation around the
189 external/internal axis. This marker placement and kinematic modelling were used in previously
190 published articles.^{7,19}

191 Marker trajectory and ground reaction force signals were both filtered with a low pass
192 Butterworth filter (4th order, 15 Hz cut-off frequency) prior to calculating external joint

193 moments with a standard inverse dynamics approach. Three-dimensional kinematic data of the
194 trunk segment and hip joint were analyzed to understand the influence of FBCS on trunk
195 positioning. Three-dimensional kinematics and kinetics of the knee joint were further analyzed
196 to determine the influence of FBCS on knee joint stability and loading. Both kinematics and
197 kinetics were measured during cutting maneuvers, but only kinematics was observed during
198 LRJ. These variables were analyzed at the time of their peak values during the first half of
199 ground contact during LRJ, to give some insights into how the apparel condition influences the
200 range of motion of the different body segments. However, during cutting maneuvers, the
201 different variables were determined at the time of peak knee abduction moment, as this is a
202 relevant parameter associated with knee injury.²⁵

203 Trunk lateral lean and trunk axial rotation were defined relative to the global coordinate
204 system, i.e. deviations from the vertical axis and from the anterior-posterior axis, respectively.
205 Both were positive for an orientation in the new movement direction (i.e. to the right direction).
206 Hip rotation, knee rotation and knee rotation joint moment were defined as positive for an
207 external rotation.

208 The time to accomplish the 5-10-5 yards test served as outcome measure for agility.
209 CMJ height was calculated based on the flight time method. During cable lift testing, the
210 vertical acceleration signal of the accelerometer (University of Sport Science, Freiburg,
211 Germany) placed on the top of the weight stack was filtered with a low pass Butterworth filter
212 (4th order, 20 Hz cut-off frequency) and then integrated to obtain velocity. Based on Newton's
213 second law, lift force was calculated. Finally, power was determined by means of the product
214 of force and velocity.

215 The selected parameters were averaged across eight trials for the different LRJ
216 modalities and the 45° cutting maneuver, while the time during the 5-10-5 yards test was
217 reported, and the highest CMJ and mean peak power value over two cable lift trials were

218 calculated. These parameters served as the basis for the statistical analysis (Statistica 12,
219 StatSoft, Inc.®, Tulsa, OK, US). All results are presented as group mean \pm standard deviation
220 (SD). After having confirmed that data followed a normal distribution (Shapiro-Wilk W),
221 sphericity was verified by means of the Mauchly's test. The influence of the apparel condition
222 on dependent variables for LRJ modalities was calculated using a two-way analysis of variance
223 (General Linear Model) with repeated measures to test for main effects of and interactions
224 between apparel (Control vs. FBCS) and LRJ modality (stable vs. sliding vs. counteracting). If
225 a statistically significant LRJ modality main effect was observed, Bonferroni corrected paired
226 comparisons determined where the differences occurred. The influence of the apparel condition
227 (Control vs. FBCS) on the dependent variables for the cutting maneuver and performance tasks
228 was analyzed using paired two-tailed t-tests. The magnitude of the changes was assessed with
229 effect size (ES) and 95% confidence interval (CI). The ES was evaluated by means of partial
230 eta squared (η^2_p) values and were considered small (.01 - .06), medium (.06 - .14) and large
231 ($> .14$) according to Cohen²⁶. The level of significance was set at $P < .05$.

232

Results

233 There was a significant main effect of the apparel condition on hip rotation, knee
234 abduction and rotation during LRJ (Table 1). Hip joint internal rotation was increased with
235 FBCS ($P = .019$), while knee joint abduction and internal rotation were reduced ($P = .002$ and
236 $P < .001$, respectively). Statistical analysis revealed a significant main effect of the LRJ
237 modality on trunk forward lean and trunk lateral lean ($P = .025$ and $P = .003$, respectively), hip
238 flexion, abduction and rotation ($P < .001$ for all), knee flexion and rotation (both $P < .001$).
239 However, no interaction effect (apparel condition x LRJ modality) was reported. Specifically,
240 pairwise comparisons revealed that stable, sliding and counteracting modalities yielded
241 significantly different values from each other for trunk lateral lean ($P < .004$ for all), hip flexion
242 ($P < .001$ for all), hip rotation ($P < .003$ for all), knee flexion ($P < .001$ for all) and knee rotation

243 ($P < .003$ for all). Trunk flexion was significantly greater during counteracting than both stable
244 ($P < .02$) and sliding ($P < .001$). Hip abduction was significantly greater during sliding than
245 both stable ($P < .001$) and counteracting ($P < .001$).

246 During the cutting maneuver, trunk forward lean and axial rotation were not influenced
247 by the apparel condition at the time of peak knee abduction moment, while trunk lateral lean
248 was significantly increased by FBCS ($P < .001$). Hip joint internal rotation was higher for FBCS
249 than Control ($P = .003$). Knee joint angles and moments, especially the knee abduction moment,
250 were not influenced by the apparel condition (Table 2). The ensemble averages of trunk lateral
251 lean and knee joint abduction moment over the stance phase of the cutting maneuver are
252 presented (Figure 2).

253 Performance parameters were not significantly influenced by the apparel condition. The
254 sprint time measured during the 5-10-5 yards test was comparable between the two apparel
255 conditions (5.6 ± 0.3 s for both conditions; $P = .90$, 95% CI [-0.15, 0.13], $\eta^2_p = .002$). CMJ
256 height was not significantly different between Control and FBCS conditions (0.28 ± 0.05 m for
257 both; $P = .40$, 95% CI [-0.01, 0.01], $\eta^2_p = .07$). Mean peak power produced by the participants
258 during the cable lift did not differ significantly ($P = .55$, 95% CI [-6, 11], $\eta^2_p = .03$) when
259 performing the movement in the Control condition (282 ± 69 W) or with FBCS (280 ± 68 W).

260

261 Discussion

262 The main findings of the study were as follows: 1) FBCS did not reduce trunk angles
263 during lateral movements, with even an increased trunk lateral lean during cutting maneuvers;
264 2) hip internal rotation was increased with FBCS; 3) knee joint moments were not reduced with
265 FBCS; and 4) performance level was kept at the same level.

266 Perturbed lateral reactive jumps yielded significantly different segment and joint
267 configurations at the time of their peak values. A detailed analysis of the influence of LRJ

268 modality at the time of initial contact has already been provided in the literature.²⁷ But during
269 perturbed lateral reactive jumps, trunk positioning was not influenced by the compression
270 garment. It seems that despite a suit design enabling a reduced passive trunk range of motion,
271 FBCS cannot support the trunk segment during an active dynamic movement. Thus, the trunk
272 segment was not supported either during cutting maneuvers. On the contrary, trunk lateral lean
273 was even significantly increased by 4° while wearing FBCS during 45° cutting maneuvers.
274 While all participants showed greater trunk lateral lean with FBCS than without apparel, five
275 subjects reached particularly large values around 15° with FBCS. Although literature
276 demonstrated that compression garments could reduce the active range of motion of the hip
277 joint during a non-athletic task¹³ and during sprinting,¹⁴ a more neutral trunk positioning
278 through apparel could not be achieved during unanticipated lateral movements. It might be
279 possible that participants would rely on the support of the suit according to the compression
280 and elasticity properties felt by the participants, thereby reducing their active trunk muscle
281 control. But the lack of apparel support would bring participants to this higher trunk lateral lean
282 in the frontal plane during cutting maneuvers.

283 The specific FBCS linked shoulders with knees across the pelvis in the back thanks to the elastic
284 straps design. But at the hip joint level, only hip internal rotation was altered. The hip internal
285 rotation observed in the present study is consistent with literature during lateral reactive jumps²⁷
286 and cutting manoeuvres.²⁸ However, increased peak internal rotation values with FBCS might
287 rather reflect a lack of strength in the external hip rotators in female athletes,²⁹ exacerbated by
288 the additional tension of the compression garment.

289 It appears that external passive support with the aim of enhancing trunk positioning
290 during dynamic lateral movements classically encountered during team sports is difficult to
291 achieve with apparel. At this point, further improvements to the design of the compression suit
292 does not seem possible as several years of research and development were needed to yield this

293 current comfortable full-body suit, which enables reduced passive trunk flexibility through the
294 combined compression and elasticity properties. In addition, garments were customized to each
295 participant in the present study. Further increasing the compression level of the suit to further
296 support body segments, i.e. by reaching typical values of compression socks > 15 mmHg,³⁰
297 does not seem possible given that i) the straps used already increase the stiffness of the suit and
298 ii) the higher compression level would reduce the comfort level necessary to perform whole-
299 body dynamic movements.

300 Trunk and hip control alterations with FBCS could have consequences at the knee joint
301 level. Indeed, higher trunk lateral lean during cutting maneuvers while wearing FBCS might be
302 associated with increased knee joint loading.^{6,7} In present study, higher trunk lateral lean had
303 no deleterious influence on the knee joint, as no significant difference in knee abduction
304 moment was evident between FBCS and control conditions. Increased peak internal hip rotation
305 angles with FBCS might reflect a lack of strength in the external hip rotators²⁹ and further a
306 critical knee joint position (position of no return), where the hip moves more rapidly into
307 adduction and internal rotation and the knee collapses in valgus.³¹ But the consequences at the
308 knee joint level during lateral reactive jumps were rather a reduction of the abduction and
309 internal rotation angles whatever the landing condition with FBCS which speaks in favor of
310 better knee joint alignment. Thus, alteration of trunk positioning during lateral movements with
311 FBCS was not associated with changes in knee joint stability.

312 This result does not support the theoretical model proposed by Hewett and Myer³ and is not in
313 agreement with experimental results, where increased trunk lateral lean was associated with
314 increased knee joint abduction moment.^{6,7} This finding underlines the fact that trunk positioning
315 only partially influences knee joint loading, and that relatively small trunk angle variations (4°),
316 albeit significant, may not always have an effect on knee abduction moment, especially when
317 considering the large variability of this knee joint loading parameter.

318 It is worth noticing that FBCS had no influence on any of the performance parameters.
319 The same level of agility while wearing the compression suit or in the control condition during
320 the 5-10-5 yards test is consistent with the literature.^{13,16,32} Although improvement of jumping
321 performance with a compression garment has been reported in the literature,^{14,33} it is interesting
322 to note that jump height was not impaired with the compression suit targeting trunk and pelvis
323 positioning rather than the lower limbs in the present study. Finally, core strength during the
324 cable lift task was kept at the same level when performed with FBCS. Accordingly, FBCS can
325 be used by athletes without risk of compromising performance.

326 This study has some limitations that need to be considered. The moderate reliability of
327 knee kinetics during dynamic tasks such as cutting tasks would suggest the need for a greater
328 sample size than 12 participants.³⁴ In the present study, measured variables were assessed over
329 eight trials to ensure representative values for each participant. But the inter-subject variability
330 was pretty high for joint kinetics and the associated statistical power low (< 0.2). Thus, future
331 studies would possibly need a larger sample size to tease out effects on knee joint kinetics or at
332 least enable to discuss the lack of difference in knee joint loading. Another potential limitation
333 was the use of a cable lift task. While this test seems to be relevant to evaluate core strength,
334 the validity and reliability of this measure would need to be assessed to determine its
335 measurement error. This will allow evaluating the importance of observed differences from a
336 statistical perspective as well as in terms of its practical implication.

337 Even if compression and elasticity properties were combined with this customized full
338 body compression suit, trunk kinematics could not be favorably influenced. Achieving external
339 support of trunk positioning in female athletes through apparel seems to be difficult during
340 unanticipated lateral movements. However, a full body compression suit did not impair any of
341 the performance parameters and even yielded a better alignment of the knee during lateral
342 reactive jumps.

343

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446

Tables

Table 1 Mean \pm SD values of the different kinematic variables during lateral reactive jumps (LRJ) performed in Control and full body compression suit (FBCS) conditions.

Variable	Control (pooled LRJ)	FBCS (pooled LRJ)	<i>P</i> value	95% CI	ES (η^2_p)
Trunk Forward Lean ($^\circ$)	32.0 \pm 6.2	31.6 \pm 6.8	.66	[-1.7, 2.5]	.02
Trunk Lateral Lean ($^\circ$)	-7.5 \pm 5.4	-7.9 \pm 6.1	.63	[-1.4, 2.2]	.02
Trunk Right Axial Rotation ($^\circ$)	4.6 \pm 9.4	6.7 \pm 9.3	.10	[-4.7, 0.5]	.23
Hip Flexion ($^\circ$)	50.6 \pm 8.9	51.1 \pm 13.3	.84	[-5.5, 4.5]	< .01
Hip Abduction ($^\circ$)	35.5 \pm 4.7	35.7 \pm 5.7	.84	[-2.5, 2.0]	< .01
Hip Ext. Rotation ($^\circ$)	-5.0 \pm 6.5	-11.1 \pm 6.2*	.019	[1.2, 10.9]	.41
Knee Flexion ($^\circ$)	59.0 \pm 5.3	59.9 \pm 5.1	.10	[-2.0, 0.2]	.23
Knee Abduction ($^\circ$)	10.3 \pm 6.7	5.3 \pm 3.9**	.002	[2.3, 7.5]	.61
Knee Ext. Rotation ($^\circ$)	-13.5 \pm 7.4	-8.6 \pm 6.5***	<.001	[-7.3, -2.6]	.66

The influence of the apparel condition is reported using *P*, 95% confidence interval (95%CI) and effect size (ES) with partial eta squared (η^2_p) values.

*, **, *** indicates significant differences between Control and FBCS with $P < .05$, $P < .01$ and $P < .001$, respectively.

Table 2 Mean \pm SD values of the different kinematic and joint moment variables during cutting maneuvers performed in Control and full body compression suit (FBCS) conditions.

Variable	Control	FBCS	<i>P</i> value	95% CI	ES (η^2_p)
Trunk Forward Lean ($^\circ$)	12.6 \pm 7.8	13.9 \pm 5.6	.22	[-3.6, 0.9]	.14
Trunk Lateral Lean ($^\circ$)	-5.1 \pm 3.7	-8.7 \pm 5.0***	<.001	[2.2, 5.0]	.74
Trunk Right Axial Rotation ($^\circ$)	-8.5 \pm 8.4	-7.8 \pm 7.5	.61	[-3.4, 2.1]	.02
Hip Flexion ($^\circ$)	51.6 \pm 6.7	49.3 \pm 10.6	.35	[-2.9, 7.5]	.08
Hip Abduction ($^\circ$)	8.4 \pm 8.9	7.7 \pm 5.9	.59	[-2.2, 3.7]	.03
Hip Ext. Rotation ($^\circ$)	-4.2 \pm 7.3	-9.8 \pm 4.4**	.003	[2.4, 8.8]	.57
Knee Flexion ($^\circ$)	28.3 \pm 5.0	28.0 \pm 6.1	.56	[-0.9, 1.6]	.03
Knee Abduction ($^\circ$)	4.7 \pm 3.1	2.7 \pm 3.1	.054	[-0.1, 4.1]	.30
Knee Ext. Rotation ($^\circ$)	-7.4 \pm 6.6	-3.4 \pm 5.2	.052	[-8.1, 0.1]	.30
Knee Flexion Moment (Nm.kg ⁻¹)	0.16 \pm 0.65	0.20 \pm 0.75	.74	[-0.33, 0.24]	.01
Knee Abduction Moment (Nm.kg ⁻¹)	1.31 \pm 0.46	1.20 \pm 0.46	.30	[-0.12, 0.35]	.1
Knee Ext. Rotation Moment (Nm.kg ⁻¹)	-0.13 \pm 0.11	-0.16 \pm 0.12	.42	[-0.06, 0.13]	.06

The influence of the apparel condition is reported using *P*, 95% confidence interval (95%CI) and effect size (ES) with partial eta squared (η^2_p) values.

** , *** indicates significant differences between Control and FBCS with *P* < .01 and *P* < .001, respectively.

Figure Captions

Figure 1 - Participant wearing the customized full body compression suit (FBCS) with 2x thermoplastic polyurethane layers (TPU). The FBCS design provides support for the trunk over the pelvis segment through the 2x TPU layers that link the upper body with lower limbs across the pelvis in the back (right). The customized apparel production ensures a perfect fitting for each participant.

Figure 2 - Ensemble averages of lateral trunk flexion in the frontal plane and knee joint abduction moment for Control (black line) and full body compression suit (FBCS, grey line) during the foot contact phase of the cutting maneuver.