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Research Article

Dynamic knee valgus in anterior cruciate ligament non-contact injury and reinjury in professional female athletes. Determinant or not?

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Abstract

Dynamic Knee Valgus (DKV) is correlated with both, Anterior Cruciate Ligament (ACL) injury and hip and ankle disorders in female athletes and has a more significant prevalence compared with male athletes because of numerous factors.

The aim of this study is to determine if the connexion between DKV, landing errors, and non-contact ACL injury and re-injury in high-performance, adult, female team sport athletes can be eliminated by changing the frontal plane movement pattern and the landing errors during the rehabilitation process (RHB), a process which was focussed on dynamic knee stability with multidimensional single-leg jump landing training, on 3D knee balance improvement and multistimulus perturbation challenges and tasks,+ eccentric & concentric exercise, strength & conditioning, aerobic training that lasted from 26 - 44 weeks.

Assessing and eliminating-reducing DKV during the RHB is mandatory in lowering the re-rupture rates in female professional athletes after ACL surgery and in preventing opposite knee trauma.

Introduction

Dynamic Knee Valgus (DKV) is a complex anatomic and biomechanic pathology that is associated with both, Anterior Cruciate Ligament (ACL) injury and hip and ankle disorders [1], weaker hip abductor muscles-gluteus medius and magnus, larger pelvis with increased Q angle and flat forefoot are all conditions which can determine this biomechanical abnormality-and this condition is much more prevalent in female athletes and has a bigger functional impact in female athletes compared with male athletes because of additional biomechanical and hormal factors like -lower levels of testosterone, hormonal inhibitions and variations during luteal phases of menstrual cycles, hormonal induced ligament laxity for females who come back in the first 12 - 16 months after childbirth- and habitual factors- wrong biomechanical jump and landing patterns developed at early ages Figure 1.

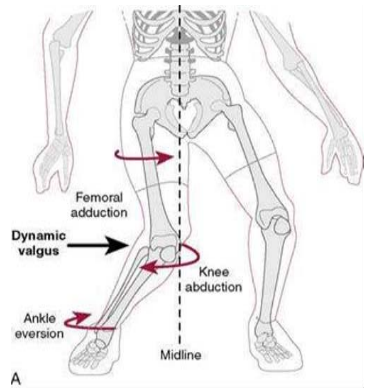

Figure 1: [5].

The aim of this study is to determine if the connexion between DKV, landing errors, and non-contact ACL injury and re-injury in high-performance, adult, female team sport athletes can be eliminated by changing the frontal plane movement pattern and the landing errors during the rehabilitation process by both plyometric training and hip stability development [2].

This is aimed at reducing very high rates of reinjury after ACL reconstruction in females, especially in young adults.

Methods

We examined and included in our study 41 female professional athletes, between 18 and 34 years old, practicing team sports in the first national leagues of handball (*n* = 27), basketball (*n* = 11), soccer (*n* = 2) and 1 volleyball (*n* = 1), all operated or re-operated because of non-contact ACL injury between 2019-2022. Our follow-up was a minimum of 36 months in all cases.

Primary ACL surgery was done by the same surgeon and an arthroscopic technique was performed, we used a Soft Tissue graft, the revision was performed with a patella bone graft; resorbable interference screws were used in all cases for tibial fixation, and femural fixation was realized with TightRope Button - Arthrex. No graft under 8 mm diameter was used, all grafts between 7 mm – 8 mm were reinforced using Fibertape -Arthrex, also grafts under 7 mm were braided to obtain 8 mm grafts Figures 2,3.

All athletes were investigated during the RHB, between 12 - 18 weeks-WKS-after surgery for isometric strength [measured on EasyTorque 3.0 from Tonus producer -E.T.3.0]-and for altered frontal plane knee movements and abnormal leg biomechanics with the Landing Error Scoring System(LESS), bilateral -indicating increased level of DKV-which was present in 34 cases (83%) Table 1-scores higher then 6-high AClL Injury risk & DKV.

Flat Forefoot was ruled out in 33 of these cases-97%, the remaining case was orthotic corrected and was included in the study Figures 4,5.

First presented in 2009, the Landing Error Scoring System (LESS)* is a clinical tool used to assess jump-landing biomechanics. It was developed to identify individuals at risk of anterior cruciate ligament (ACL) injury and is performed with a subject completing a Drop-Vertical Jump (DVJ) whilst video recorded from two planes (frontal and sagittal).

Being an easier, faster, and cheaper field-based variant of a complete biomechanical assessment, it can be performed without expensive laboratory equipment [3].

Measurement of the knee valgus angle is one of the main factors which can be objectively used in correction evolution [4].

Results

The RHB process was focused on dynamic knee stability with multidimensional single-leg jump landing training from varying heights-0,3 - 0,9 m, on 3D knee balance

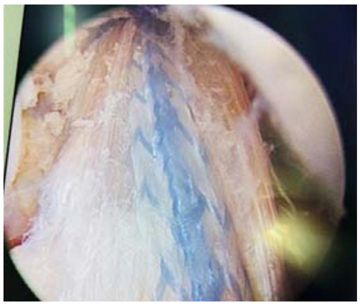

Figure 2: Graft Augmentation.

Figure 3: Graft Braidings.

Figure 4: Isometric measurements.

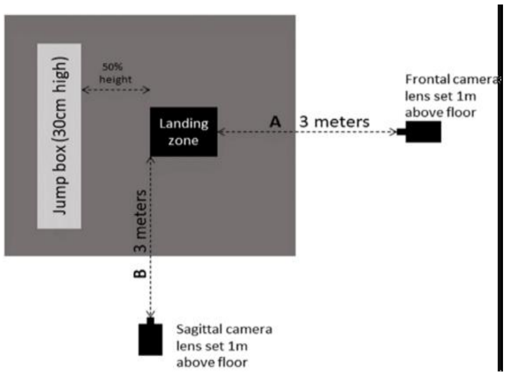

Figure 5: LESS measurements.

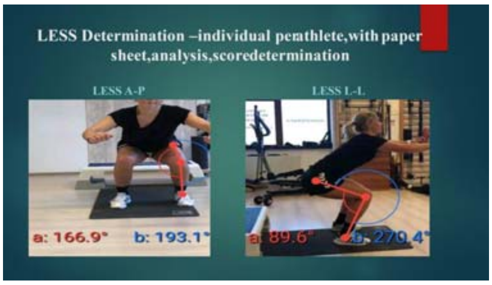

Figure 6: LESS Determination-individual parathlete, with paper sheet, analysis, score determination.

LESS Item	Operational Definition of Error	Scoring	Item
KNEE FLEXION: INITIAL CONTACT	The knee is flexed less than 30° at initial contact	0 – Absent 1 – Present	
HIP FLEXION: INITIAL CONTACT	The thigh is in line with the trunk at initial contact	0 – Absent 1 – Present	
TRUNK FLEXION: INITIAL CONTACT	The trunk is vertical or extended on the hips at initial contact	0 – Absent 1 – Present	
ANKLE PLANTAR FLEXION: INITIAL CONTACT	The foot lands heel first or with a flat foot at initial contact	0 – Absent 1 – Present	
MEDIAL KNEE POSITION: INITIAL CONTACT	The centre of the patella is medial to the midfoot at initial contact	0 – Absent 1 – Present	
LATERAL TRUNK FLEXION: INITIAL CONTACT	The midline of the trunk is flexed to the left or right side of the body at initial contact	0 – Absent 1 – Present	
STANCE WIDTH: WIDE	The feet are positioned greater than shoulder width apart (acromion processes) at initial contact.	0 – Absent 1 – Present	
STANCE WIDTH: NARROW	The feet are positioned less than shoulder width apart (acromion processes) at initial contact.	0 – Absent 1 – Present	
FOOT POSITION: EXTERNAL ROTATION	The foot is externally rotated more than 30° between initial contact and maximum knee flexion	0 – Absent 1 – Present	
FOOT POSITION: INTERNAL ROTATION	The foot is internally rotated more than 30° between initial contact and maximum knee flexion.	0 – Absent 1 – Present	
SYMMETRIC INITIAL FOOT CONTACT: INITIAL CONTACT	One foot lands before the other foot or one foot lands heel to toe and the other foot lands toe to heel.	0 – Absent 1 – Present	
KNEE FLEXION DISPLACEMENT	The knee flexes less than 45° between initial contact and maximum knee flexion.	0 – Absent 1 – Present	
HIP FLEXION DISPLACEMENT	The thigh does not flex more on the trunk between initial contact and maximum knee flexion.	0 – Absent 1 – Present	
TRUNK-FLEXION DISPLACEMENT	The trunk does not flex more between initial contact and maximum knee flexion.	0 – Absent 1 – Present	
MEDIAL KNEE DISPLACEMENT	At the point of maximum medial knee position, the centre of the patella is medial to the midfoot.	0 – Absent 1 – Present	
JOINT DISPLACEMENT	Soft: the participant demonstrates a large amount of trunk, hip and knee displacement Average: the participant has some, but not a large amount of trunk, hip, and knee displacement Stiff: the participant goes through very little, if any, trunk hip and knee displacement	0 – Soft 1 – Average 2 – Stiff	
OVERALL IMPRESSION	Excellent: the participant displays a soft landing with no frontal-plane or transverse-plane motion. Average: all other landings Poor: the participant displays large frontal-plane or transverse-plane motion, or the participant displays a stiff landing with some frontal-plane or transverse-plane motion.	0 – Excellent 1 – Average 2 – Poor	

Table 1: LESS scoring [3].

improvement-BOSU ball, Balance Boards, and multistimulus perturbation challenges [5] and tasks [throwing, catching balls, Therabands, pulling in different directions, pushing, pulling by trainer],+eccentric & concentric exercise, strenght & conditioning, aerobic training and lasted from 26-44WKS with normalized LESS score[lower than 5].

Multivariate analysis of Landing Kinetic factors during the rehabilitation process showed significant differences between two LESS scores at different time frames so an altered landing mechanism is considered a predictor of non-contact knee injuries such as ACL rupture [6] this is why it is so important to be addressed Figure 6.

Average Return To Play was in 32.1 weeks (WKS) with an SD of +1,2 WKS ranging from 28-35 WKS, after tests on " EasyTorque" 3. o-Tonus- passing criteria were more than 95% bilateral limb symmetry.

The "Triple One-Leg Hop Test"-"Cross-over One-Leg Hop Test" at 95% - 98% on both legs-normal cardiovascular endurance-Cooper test was used for assessment and psychological readiness to perform again was reached in all cases. Reaching the preinjury level of individual performance took between 40-48WKS and was considered when the player was integrated into normal team rotation, which preinjury number of game minutes&eficiency, points depending on the sport.

From 34 cases, 1 athlete re-injured after RHB, friendly game, at 32WKS after surgery (3%), 2 athletes injured after RHB, in competition -the opposite ACL in the first 48WKS after ACL surgery (6%)-1 basketball player did not return to professional level mostly because of psychological factors-fear of reinjury, lack of motivation-1 handball player quit the sport after re-injuring in competition at 50WKS, deciding to have a child.

Diagram 1 shows us in the first group of columns the total number of ACL injuries with red and with blue the number of patients who had DKV when injured.

The second row of columns shows with red the number of patients with an ACL injury who successfully returned to high-performance sports and with blue the re-injured ones after our program.

Considering the fact that female athletes with dynamic knee valgus are considered a high-injury risk category for ACL ruptures, especially during team-pivoting-contact sport, we consider that trying to correct through Neuroplasticity and specific rehabilitation (Neuroplasticity - which is the capacity of the brain to learn new movement patterns and to establish new connexions in the motor cortex through synaptogenesis and neurogenesis) and trying to positively alter the biomechanics throughout the rehabilitation process is an achievable goal.

In Table 2 we have the LESS score measurement of our

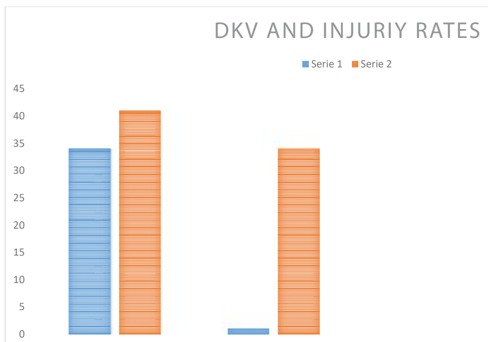

Diagram 1: Total ACL Injuries-red /DKV athletes-blue; Reinjury rates in patients which corrected DKV-blue.

Nr crt	NAME	SPORT	LESS SCORE
1	A.I.	Handball	8
2	A.D.	Handball	12
3	M.C.	Handball	8
4	A.I.	Handball	10
5	C.F.	Handball	6
6	A.D.	Handball	15
7	S.L.	Handball	9
8	D.H.	Handball	11
9	S.A.	Handball	14
10	I.H.	Handball	7
11	C.D.	Handball	11
12	F.E.	Handball	15
13	H.E.	Handball	6
14	V.E.	Handball	16
15	P.M.	Handball	11
16	T.B.	Handball	9
17	B.A.	Handball	8
18	P.T.	Handball	14
19	R.H.	Handball	12
20	C.S.	Handball	9
21	A.A.	Handball	9
22	H.Z.	Handball	16
23	L.C.	Handball	15
24	A.C.	Handball	5
25	A.M.	Handball	6
26	F.M.	Handball	5
27	D.A.	Handball	5
28	S.D.	Basketball	13
29	O.D.	Basketball	14
30	S.H.	Basketball	10
31	C.S.	Basketball	17
32	P.C.	Basketball	13
33	U.A.	Basketball	9
34	B.A.	Basketball	16
35	M.C.	Basketball	7
36	A.T.	Basketball	4
37	K.S.	Basketball	5
38	F.D.	Basketball	5
39	A.I.	Volleyball	12
40	C.L.	Soccer	14
41	T.C.	Soccer	13

Table 2: LESS Results 1 LESS 12-18 Weeks after Surgery AVG-10.3 pts.

Nr crt	NAME	SPORT	LESS SCORE
1	A.I.	Handball	4
2	A.D.	Handball	Re-injured the opposite ACL at 48 WKS after RHB
3	M.C.	Handball	4
4	A.I.	Handball	5
5	C.F.	Handball	3
6	A.D.	Handball	5
7	S.L.	Handball	4
8	D.H.	Handball	3
9	S.A.	Handball	5
10	I.H.	Handball	3
11	C.D.	Handball	5
12	F.E.	Handball	4
13	H.E.	Handball	3
14	V.E.	Handball	2
15	F.M.	Handball	5
16	T.B.	Handball	4
17	B.A.	Handball	4
18	P.T.	Handball	Re-inj. at 32 weeks after RHB
19	R.H.	Handball	6
20	C.S.	Handball	4
21	A.A.	Handball	4
22	H.Z.	Handball	5
23	L.C.	Handball	5
24	A.C.	Handball	3
25	A.M.	Handball	Quit sport after re-injury at 50 WKS
26	F.M.	Handball	3
27	D.A.	Handball	4
28	S.D.	Basketball	4
29	O.D.	Basketball	4
30	S.H.	Basketball	2
31	C.S.	Basketball	Re-injured the opposite ACL after 48 WKS after RHB
32	P.C.	Basketball	5
33	U.A.	Basketball	4
34	B.A.	Basketball	9
35	M.C.	Basketball	3
36	A.T.	Basketball	4
37	K.S.	Basketball	5
38	F.D.	Basketball	Did not return to P.L.
39	A.I.	Volleyball	3
40	C.L.	Soccer	1
41	T.C.	Soccer	3

Table 3: LESS Score 22 -48 weeks after surgery AVG 4,05 PTS.

female athletes and the type of sport they are performing in, in the interval of 12 - 18 weeks after surgery, the higher the score the more dynamic knee valgus and landing errors exist.

In Table 3, we observe that the LESS score has improved through specific plyometric, neuropeptide, and strength training which means that landing errors diminished drastically, and we have better biomechanics, more pelvic stability, and hip abductor strength.

The re-injury complication rates on operated leg- 2/34 = 5,8% and on the opposite side 2/34 = 5,8% are lower than published data [7] varying from 7% - 15% ipsilateral and 8% - 10% contralateral in the first year. This is statistically significant and could be related both to the longer RHB period and DKV correction, a process that is individualized and complex [8]. Anyway, still highest rate of reinjury after ACL surgery is observed in young, female athletes who participate in pivoting contact sports [9]. Energy absorbing strategies during landings, single or bilateral leg landings must be also learned in order to reduce stress o the knee - especially axial loading and forces which would increase valgus angle [10].

Conclusion

Rates of primary ACL injuries in female sports and especially in female contact team sports are still very high despite advances in surgical techniques, materials, and in the rehabilitation process-sports like women's handball, soccer, and basketball being particularly affected [5].

Assessing and eliminating-reducing DKV during the RHB process is mandatory in lowering & re-rupture rates in female professional athletes after ACL surgery and in preventing opposite knee trauma.

Also, we strongly believe that return to sport criteria which include assessing DKV and hop tests, an additional MRI for assessing graft vascularization, and integration should be used in allowing athletes to return to the competition level.

All must be done to prevent an injury and re-injury – a well-designed program like FIFA 11 is very effective and should be implemented [11].

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