SCREENING TEST FOR THE POTENTIAL RISK OF ACL RUPTURE OF FEMALE AND MALE SOCCER PLAYERS

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ACL rupture is a devastating injury. An analysis of risk factors and a consecutive prevention program might help to reduce the risk of injury. However there exists no screening test to identify the individual ACL-injury risk. The purpose of this study was to develop a screening test by which the potential risk of ACL rupture for female and male soccer players can be estimated. Testing procedure focussed on dynamical knee valgus in frontal plane during landing of a drop jump in normal and fatigued state. The results were obtained by 2D video analysis. Results show a wide range of dynamical knee valgus in both sexes with a 5.4 cm greater dynamical valgus of women emphasizing the distinctly higher risk potential for ACL injury of women. Screening tests seem to be suitable to achieve an estimation of the individual risk for ACL injuries without large expenditure.

KEYWORDS: ACL, prevention, soccer, fatigue, screening test.

INTRODUCTION:

Rupture of the anterior cruciate ligament (ACL) is a devastating knee injury for the athlete with a long phase of rehabilitation and inability to perform sports. Additionally it may cause degenerative changes of joint. Most frequent situations causing ACL ruptures (review in Alentorn-Geli et al. 2009a) are landing positions after a jump, or stopping, plant and cut manoeuvres. High risk sports are team handball, soccer and basketball. 70 to 84% of ACL injuries occur in non-contact situations. Studies have shown a 2.4 to 9.5 higher incidence of ACL rupture in women than men. Commonly risk factors have been divided into environmental, anatomical, hormonal, neuromuscular and biomechanical - simply into intrinsic (within the body) and extrinsic (outside the body) - factors. Quatman & Hewett (2009) emphasize the evidence of the “valgus collapse” mechanism in frontal and sagittal plane as strong predictor of ACL-injury risk for females. Mandelbaum et al. (2005) discussed the frontal plane dynamic knee valgus during landing in drop jump as potential risk. Prevention programs for soccer and team handball focussing on modifiable intrinsic risk factors (biomechanical and neuromuscular) have been developed mainly showing positive results (review in Alentorn-Geli et al. 2005b). Nevertheless the effectiveness of prevention programs is not yet regarded as assured (Bahr & Krosshaug 2005). Karlsson (2010) postulates the implementation of preventive measures in normal sports training on an every day basis. But there exist no screening test to identify the individual risk of ACL injury and no method to monitor training induced alterations. Such a testing could have an essential advantage to analyse individual factors of the athletes and it could contribute to the development of individual prevention programs. Therefore it was the aim of the present study to develop a simple screening test for to estimate the potential risk of ACL rupture of female and male soccer players.

METHODS:

Two junior soccer teams (U17) of both sexes, 15 female players (15.5 ± 1.1 yrs , 65.9 ± 8.7 kg, 170.1 ± 6.0 cm) and 15 male players (15.7 ± 0.7 yrs, 71.7 ± 7.2 kg, 180.5 ± 8.4 cm) without acute injuries or former ACL ruptures participated in the study. After a 5 minute warm-up on a cycle ergometer an isometric strength test was carried out (Cybex norm) consisting of 3 MVCs of knee flexor (45° knee angle) and extensor (90° knee angle) muscles in randomized order. Next the young players performed 3 drop jumps from a height of 40 cm and also of 60 cm (Huston et al. 2001) in rested and - after an exhausting stepping exercise - in fatigued state. Finally a second isometric strength test was carried out. For the right and the left leg two 3-dimensional force plates (Kistler) were used to measure ground reaction forces with a sampling frequency of 1000 Hz. Two video cameras (JVC, 50 Hz) in frontal and sagittal plane were used to determine dynamic knee valgus and knee angle between the first contact to ground and the deepest bending position. Video and force plate data were synchronised and stored with the software Simi-Motion. 2D-analysis was performed by Simi Twinner Pro. In frontal plane horizontal distances between left and right knee (knee distance, KD) as well as between left and right foot at ankle height (foot distance, FD) at ground contact as well as in the deepest bending position were measured by 2D analysis, also knee angle in sagittal plane. A position with a lower KD than FD is defined as a valgus position (VP). A decreasing knee distance between ground contact and deepest bending position is defined as dynamic knee valgus (DKV). The results were processed by the means of Simi-Motion, Simi-Onforce and Excel. Furthermore SPSS V.17 was used for statistical analysis.

RESULTS: Results of isometric MVCs (tab. 1) show (except female right leg) a significant reduction of quadriceps force (♀ -4.4%, ♂ -7.0%) after exhausting exercise, but no significant changes in hamstring force. Male players show significant higher forces (absolute: quadr. 51%, hamstr. 43%; in relation to body weight: quadr. 38%, hamstr. 32%) under all conditions.

Table 1. Isometric MVC [Nm] of quadriceps (quadr.) and hamstrings (hamstr.) in rested und fatigued state, t-test (p).

		quadriceps		Hamstrings		t-test (p)	
		Normal	**fatigue**	**Normal**	**Fatigue**	**quadr.**	**hamstr.**
female	**left**	151.1 ±29.5	140.9 ±20.1	110.0 ±14.4	113.7 ±11.3	**0.028**	0.070
	right	152.1 ±27.7	149.1 ±25.5	109.5 ±25.7	115.8 ±18.8	0.252	0.058
male	**left**	230.6 ±51.0	219.9 ±49.3	155.5 ±32.1	163.2 ±27.2	**0.034**	0.061
	right	232.1 ±58.7	210.5 ±37.3	162.8 ±31.6	162.2 ±27.8	**0.015**	0.439
t-test (p)	**left**	**0.001**	**0.000**	**0.000**	**0.000**		
sex	**right**	**0.001**	**0.000**	**0.000**	**0.000**		

Results of drop jumps (tab. 2, fig. 1) show the same FD (28.6 ±3.8 cm) for male and female players in the moment of first ground contact at landing. KD of women at ground contact is at least significantly lower (-3.0 ±2.9 cm) than FD. In contrast KD of men does not show a significant difference to FD (-1.5 ±2.5 cm). Up to the deepest bending position, women show a significant increased VP (-7.9 ±4.8 cm) synonymous to a DKV. In contrast the slightly increased VP of men (-2.4 ±4.8 cm) is not significant. Additionally there is a significant greater jump height of men (♂ 20.7 ±6.1 cm, ♀ 17.2 ±3.7 cm). The force results of drop jumps related to body weight show no significant gender differences.

Table 2: FD, KD and VP at landing (ld) resp. at deepest bending position (dp) and DKV during drop jumps (dj) from a height of 40 cm and 60 cm in rested und fatigued (f) state, t-test (p)

		horizontal distance [cm]			valgus [cm]		t-test (p)	
							FD	**KD ld**
	dj	**FD**	**KD ld**	**KD dp**	**DKV**	**VP dp**	**KD ld**	**KD dp**
Female	**40**	28.9 ±4.9	25.3 ±3.0	21.0 ±4.1	-4.3 ±3.7	-8.0 ±5.2	**0.020**	**0.003**
	40f	28.4 ±3.6	25.5 ±3.0	20.0 ±4.1	-5.5 ±4.4	-8.4 ±5.2	**0.034**	**0.001**
	60	29.0 ±3.4	25.6 ±2.3	21.4 ±3.0	-4.2 ±3.5	-7.6 ±4.7	**0.004**	**0.000**
	60f	28.0 ±3.6	25.0 ±3.3	20.4 ±5.7	-4.6 ±4.6	-7.7 ±5.2	**0.012**	**0.000**
Male	**40**	28.8 ±3.1	27.2 ±2.7	26.3 ±4.8	-0.8 ±4.1	-2.5 ±5.2	0.134	0.558
	40f	27.5 ±4.5	27.1 ±3.3	25.3 ±6.2	-1.8 ±4.5	-2.2 ±5.0	0.792	0.323
	60	29.2 ±3.5	27.2 ±2.4	27.0 ±3.1	-0.2 ±3.8	-2.2 ±4.7	0.129	0.907
	60f	28.9 ±4.1	27.0 ±3.3	26.1 ±5.3	-0.9 ±3.8	-2.8 ±4.2	0.178	0.587
t-test (p) sex	**40**	0.921	**0.030**	**0.003**	**0.009**	**0.006**		
	40f	0.304	0.201	**0.007**	**0.004**	**0.000**		
	60	0.898	0.237	**0.006**	**0.017**	**0.010**		
	60f	0.751	0.146	**0.005**	**0.020**	**0.016**		

At ground contact KD of women is only during drop jumps from 40 cm height in rested state significant lower than KD of men, whereas in deepest bending position women show significant higher VP and DKV than men (tab. 2, fig. 1). In total 95% of women and 65% of men show an increased valgus during landing and therefore a dynamical knee valgus. Defining a DKV of at least 5 cm as criterion of an increased risk of ACL injury, 75% of women and 32% of men show an increased risk, equivalent to a 2.5 higher risk of women than men.
Comparison of sorted single values of women and men show similar results (fig. 2) independent from jump height or fatigue. Women and men show a similar range and distribution of DKV with an about 5.4 cm higher valgus of women.

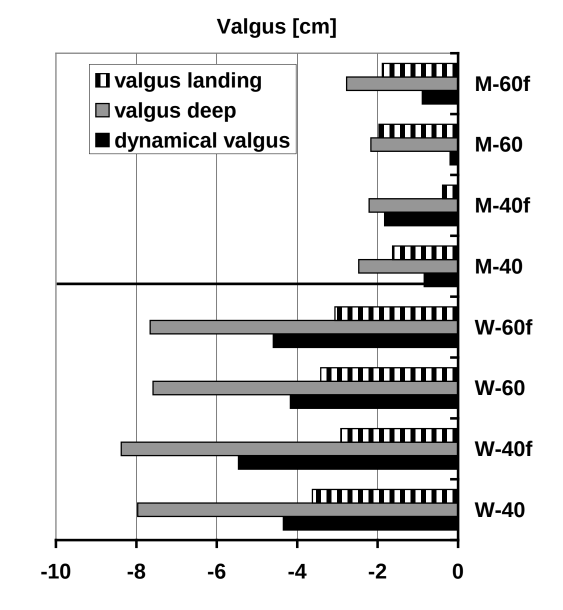

Figure 1: Valgus at landing and at deepest bending position, DKV during landing of women (W) and men (M) during drop jumps from a height of 40 cm and 60 cm in rested and fatigued (f) state (s. tab. 2).

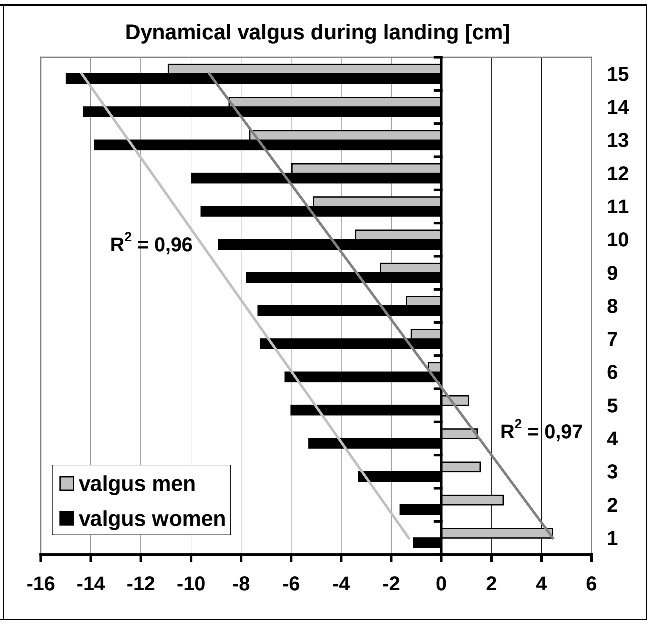

Figure 2: Sorted data of DKV [cm] of women and men during landing, individual mean values over all conditions, sorted by valgus.

Results of maximum knee angle while landing show no significant differences between women and men neither in rested (40 cm: ♀ 77.8 ±9.8°, ♂ 81.7 ±10.9°) nor in fatigued state (40 cm: ♀ 77.9°±8.7°, ♂ 83.1 ±11.3°) nor dependent on drop jump height. Higher drop jump height leads to a significant higher knee angle in both sexes (60 cm: ♀ 82.6 ±13.6°, fatigued 83.0 ±12.8°; ♂ 89.0 ±13.2°, 88.1±11.4°).

DISCUSSION: Results of MVCs show a significant but only slight reduction of quadriceps force after exhausting exercise. One reason may be the time shift of at least 15 min. between the jump test and the first MVC caused by the positioning and fixing procedure on the isokinetic testing station (cybex norm). The unchanged MVCs of hamstrings indicate that stepping was not suitable for fatigue of hamstrings. Therefore a possible fixing of tibia by hamstrings against shifting and protection of ACL was not affected by the exhausting exercise.
The study shows no dependences between DKV during landing and drop jump height or fatigue. Therefore it seems to be suitable to perform a screening test to estimate the potential risk for ACL injury with only one drop jump height of about 40 cm without fatigue.
The leg positions during landing verify the anatomical caused tendency of increased valgus deformity of females (Alentorn-Geli et al. 2009a). The higher degree of DKV of females during landing after jumps, emphasized as strong predictor of ACL-injury risk (Mandelbaum et al. 2005, Quatman & Hewett 2009), is obvious. In Addition results underline the assumption

that an increased initial valgus at ground contact also leads to a higher degree of DKV during landing - caused by working forces and torques. Against most literature (cf. Alentorn-Geli et al. 2009a) both sexes show no difference in knee angles while landing. If this could be confirmed in further investigations, a screening test might be performed without respect to knee angle.

The arbitrarily defined criterion - in the absence of an existing threshold level - of at least 5 cm dynamical valgus as indicator for a potentially higher risk of ACL injury is still unclear and has to be verified in future works. However with this assumption results show a 2.5 higher risk of females, which is in the same order as the higher risk factor of ACL injury described in literature (Alentorn-Geli et al. 2009a). Furthermore results show not only in 75% of women but also in 32% of men an increased risk of ACL injury, which was not to be seen from the group mean values. Particularly, the high range and the similar distribution of DKV seem to be an interesting finding. The higher potential risk of women is expressed by the on average 5.4 cm increased DKV. Nevertheless, it becomes quite clear that the risk of ACL injury is not limited to female athletes. In consequence an ACL prevention program (e.g. FIFA „11+“, Grimm & Kirkendall 2007) for athletes of both sexes with a higher risk potential is recommended.

CONCLUSION: The presented video-based screening test is a first step in order to achieve important hints at the potential ACL injury risk without large expenditure. It supports the hypothesis of Karlsson (2010) to implement preventive measures in normal sports training on every day basis. Identifying and monitoring ACL injury risk seems to be important regarding the fatal results of ACL injury for the athletes. Further work is to be done to verify and to refine the screening test. Here one should focus on threshold value for the DKV, sex specifity or individual foot position. All in all, it is important to investigate whether and, in particular, how prevention programs reduce the individual risk level.

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