EFFECT OF A NEUROMUSCULAR HOME TRAINING PROGRAM ON DYNAMIC KNEE VALGUS (DKV) IN LATERAL SINGLE-LEG LANDINGS

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The purpose of the study was to investigate if an intervention program with focus on neuromuscular and feedback training in a home-based setting with supervision improves the leg alignment in recreational volleyball and basketball players. 16 players ran a 6-week neuromuscular intervention program in a home setting with video-based supervision. The control group just followed the regular training program. Before and after the intervention the DKV was measured as the peak knee valgus angle during the video-recorded landing after a lateral jump from a box using a 2D video analysis tool. While the DKV improved in the training group, no changes were found for the control group. The intervention was effective and can be recommended as a knee-injury mitigation program.

KEYWORDS: knee injury prevention, neuromuscular training, knee alignment.

INTRODUCTION: Anterior cruciate ligament (ACL) injury is a serious and increasingly common sports injury. More than two million cases are reported annually worldwide (Benjaminse et al., 2017). Interestingly, 70% of ACL ruptures occur in non-contact situations, indicating that poor neuromuscular control and improper movement execution is the culprit rather than external forces (Oberhofer et al., 2017). Since the aetiology appears to be multifactorial it is recommended to focus on the modifiable neuromuscular aspects mainly represented through the dynamic knee valgus (DKV) (e.g. Hewett et al., 2006). The DKV, a movement pattern, which typically involves a combination of hip, knee and ankle movement alterations in the frontal and transverse planes, is supposed to be the primary risk factor for non-contact ACL injuries (e.g. Numata et al., 2018; Kagaya et al., 2015). A biomechanical analysis in volleyball and basketball describes the complexity of landing kinematics and the high ground reaction forces (GRF) during landing (Zahradnik et al., 2015; McClay et al., 1994). The results indicate the need for a controlled, safe landing technique, especially for lateral single-leg landings (Benjaminse et al., 2017; Wikstrom et al., 2008; Zahradnik et al., 2015).
Due to the multifactorial aetiology of non-contact ACL injury a combination of multiple treatment approaches seems to be most effective on targeting the diverse deficits. Therefore, a precise knowledge and diagnostics of the triggering factors as well as changeable factors is necessary in order to be able to make an adequate choice of intervention. Consequently, the prevention of non-contact ACL injury should focus on neuromuscular-biomechanical factors for they are the only components modifiable by training (Yoo et al., 2010). Some study designs did not directly investigate the reduction in the ACL injury risk, but the improvements in knee alignment. The importance of neuromuscular training (NMT) programs with an emphasis on feed-forward mechanisms is discussed in the literature (Riemann & Lephart, 2002). The feed-forward mechanism allows anticipated landings, maintaining balance in landing, decelerating and cutting off manoeuvres, as well as changing direction and is supposed to be one of the most important factors in order to decrease ACL injury risk (Holmes & Delahunt, 2009; Riemann & Lephart, 2002; Sañudo et al., 2019).
Recreational athletes hardly spend time in additional prevention training. An approach that might be accepted is an additive home training program with clear instructions and video-based supervision and feedback strategies.
Thus, the purpose of the study was to investigate if an intervention program with focus on neuromuscular training (NMT) and feedback training in a home-based setting with supervision improves the leg alignment (using DKV) in recreational volleyball and basketball players.

METHODS: Two groups of 16 participants each (18 f, 14 m; 18-55 yrs; Varsity recreational volleyball and basketball courses; two training sessions per week) with mean DKV of 10.7° (dominant leg) and 9.2° (non-dominant leg) participated in the study. A six-week neuromuscular intervention program (3x per week for 15 minutes) consisting of squat and jumping exercises in diverse conditions (different techniques, surfaces, additional loading, feedback, see Table 1) was executed by the intervention group (IG). The program was provided in writing and augmented with links to videos explaining each exercise in detail. Thus the training could be conducted in a home program that was supervised by video-clips provided by the participants to the supervisors of the study.

Table 1: Training program for the intervention group, numbers show the duration for each exercise in seconds (l: left leg; r: right leg)

Weeks	1	2	3	4	5	6
Wall jumps	20	25				
Wall jumps (1 kg ball)		25	25	25	20	25
Tuck jumps	20	25	25	25	20	25
Forward squat jumps			25	25		
Box jumps			25	25		
Barrier jumps (Side/Side) over object	20	25				
Barrier jumps (Front/Back)	20	25				
180° jumps	20	25				
Squat jumps	20	25				
Plank Skiers	20	25				
Press Jacks (1kg ball)	20	25				
Explosive Step up jumps			25			
X – Hops single-legged			20 l+r			
Plank jumping spider			25	25		
Split Squats jumps			20 l+r			
Skater Hops (1kg ball)				25		
Box Shuffle jumps				25		
Sitting-jump-landing single-legged			15 l+r			
Depth 180° box jumps					20	25
Barrier jumps (S/S) single-legged					20 l+r	20 l+r
Barrier jumps (F/B) single-legged					20 l+r	20 l+r
Heel raise jump with straight knee					10 l+r	15 l+r
Burpees					20	25
Sitting-jump-landing single (1kg ball)					10 l+r	15 l+r

The control group (CG) participated as the intervention group in the regular Varsity volleyball or basketball program without additional intervention. Before and after the intervention program all athletes were 2D video-recorded in frontal plane during landing after a lateral jump (70 cm sideways) from a box (35 cm high), both for the dominant and non-dominant leg. Kinovea software was used to determine the DVA as the peak knee valgus angle (trochanter major – midpoint of knee at mid-patella – midpoint of ankle joint by visual inspection) as previously presented by Sinsurin et al. (2013) and Schurr et al. (2017). The precision of the measurements (standard deviation) was lower than 0.6° in repeated determination (5x) of 10 randomly selected recordings. For statistical analysis a 2x2 ANOVA (F1: "time", F2: group" with repeated measures on "time") with post-hoc t-tests (Bonferroni corrected) was used, both for the dominant and the non-dominant leg. The level of significance level was set at $p < 0.05$.

RESULTS: The results of the study are presented in Figure 1and Figure 2. The intervention group demonstrated a significant decrease in DKV on the dominant side by 6.8° ± 2.8° (13.2° ± 6.3° (Pre) to 6.4° ± 3.8° (Post); $p<0.001$, eta = 1.0) and on the non-dominant side by 6.1° ± 2.6° (14.3° ± 8.7° (Pre) to 8.2° ± 5.3° (Post), $p<0.001$, eta=0.9). CG did not show significant changes, neither on the dominant ($p = 0.683$) nor on the non-dominant side ($p = 0.247$).

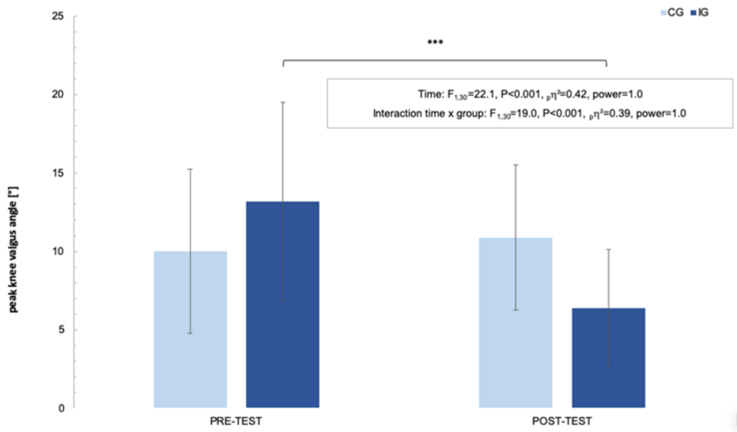

Figure 1: Peak knee valgus angle before (Pre) and after (Post) intervention period of six weeks for the intervention group (dark) and the control group (light) for the dominant leg

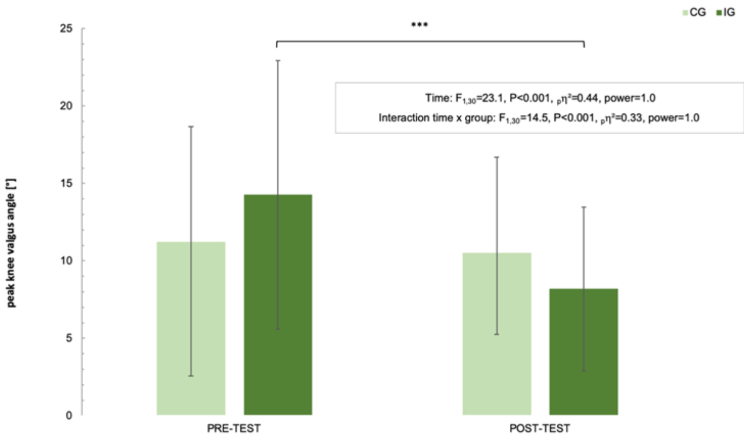

Figure 2: Peak knee valgus angle before (Pre) and after (Post) intervention period of six weeks for the intervention group (dark) and the control group (light) for the non-dominant leg

DISCUSSION: The results show that the 6-week combined neuromuscular and feedback training program in a home-based setting with video-based supervision led to a significant reduction of the peak knee valgus angle between 6° an 7° in recreational volleyball and basketball players. To the best of our knowledge this is the first intervention study in this context combining different training program approaches and a home-based training setting including supervision. Therefore, the outcome of this study cannot directly be compared to previous studies due to the combination of different settings. The results, however, are comparable to previous studies using supervised training conditions (Barendrecht et al., 2011; Czasche et al., 2018; Hopper et al., 2017; Neilson et al., 2019), pure NMT training programs (e.g. Hopper et al., 2017) or pure feedback training approaches (e.g. Myer et al., 2013; Munro & Herrington, 2014). Based on these comparisons the training setup used in this study can be interpreted as quite relevant regarding the preventive aspect. The study does not provide a direct proof that the proposed training program leads to a reduction of the incidence of ACL injuries. The program, however, showed that the athletes were able to better control and stabilize the knee in the frontal plane after lateral landings indicating at least a potential as a preventive measure for ACL injuries (Numata et al., 2018; Kagaya et al., 2015). It is also quite important to see that the organizational setup of a home-based training program with supervision seems to work for the stated purposes. The main limitations of the study are seen in the inhomogeneity of the sample, the non-randomized assignment of the participants to the two groups, the high dropout rate due to the length of the intervention program and the inaccuracies in determining the PKVA from the 2D video recordings.

CONCLUSION: A six-week neuromuscular intervention training in a self-organised and video-based supervised program is effective to improve the dynamic knee valgus and can therefore be recommended as a preventive program with the potential to reduce the prevalence of knee injuries in general and ACL ruptures in particular in recreational volleyball and basketball players.

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