TO DO OR NOT TO DO; INVESTIGATING THE EFFECTS OF POSITIVE AND NEGATIVE VIDEO INSTRUCTIONS ON SIDE-STEP CUTTING

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The purpose of this study was to examine the effects of positive and negative instructions on knee joint loading. Eighteen basketball players performed sidestep cut exercises with positive (optimal knee joint loading) and negative (suboptimal knee joint loading) visual instructions given by videos of experts performing side-step cutting. The results showed that subjects performed not significantly different compared to experts in the positive condition. The reduced knee joint loading seemed to indicate that subjects were able to imitate the experts to some extent. However, there was a significant difference between the negative condition of subjects and experts. This finding suggest that subjects could not completely copy the negative movements of the experts. Therefore, this might implicate that coaches should use experienced athletes as experts when demonstrating exercises to promote the highest learning effect.

KEYWORDS: ACL, INJURY PREVENTION, OBSERVATIONAL LEARNING

INTRODUCTION: Despite of injury prevention initiatives, the rate of anterior cruciate ligament injuries has unfortunately remained unchanged or slightly increased the last years (Agel et al., 2016). For injury prevention to be effective in the real-world, an effective transfer to the complex, unpredictable game environment has to be realized. One reason for the suboptimal transfer to the real-world could be suboptimal training of motor skills. In current injury prevention programs, exercises are most often executed in a closed predictable environment where focus lies on conscious awareness to lower extremity, also called an internal focus of attention (IF) (Wulf et al., 2010). For example, commonly used instructions in those current programs are ‘bend your knee while landing’ and ‘do not let you knee buckle inwards’

However, negatively phrased instructions, such as the last one, hinder performance (e.g. Bakker, et al., 2006). Movements are performed more efficiently when instruction highlights what to do opposed to what not to do (e.g. de la Peña et al., 2008). Instructing someone not to perform a particular action make them even more likely to execute that action (Wegner, 1994), even more when they are under cognitive load (Wegner, 2009). Giving athletes explicit instructions to perform movements which needs to be processed, increases the cognitive load. According to the constrained action hypothesis, an IF leads to conscious awareness (such as ‘do not lend your knee buckle inwards’) and may constrain automatic control processes that would normally regulate the movement (Wulf et al., 2001) and is highly needed on the field. Contrary, an external focus of attention (EF) allows the motor system to more naturally self-organize, unconstrained by the interference caused by conscious control attempts, resulting in more effective learning (Wulf et al., 2001). Previous research has already shown that an EF leads to better motor learning, i.e. retention and transfer, compared to an IF (Benjaminse et al., 2018; Wulf, 2013).

Observational learning seems to be one powerful opportunity to promote adoption of an EF. It is thought to be an effective way to enhance motor learning, especially when observation is combined with physical practice (Shea et al, 2000; Shebilske et al., 1992) which results in a more flexible and generalizable capability (Wulf et al., 2010). It promotes a more implicit way of motor learning as the learner will explore, and then select the movement solution that fits best in their body. Imitation (copying body movements that are observed) plays an important role in observational learning (Brass & Heyes, 2005). Mirror neurons facilitate motor learning by mapping observed movements onto a motor program (Rizzolatti et al., 2009). These visuomotor neurons fire when an action is performed and when a similar action is passively observed (Rizzolatti & Craighero, 2004) and thus play an important role in linking visual input with motor output. For example, the contour of an expert video with an optimally performed drop vertical jump task resulted in successfully improved landing technique without reducing performance compared to the IF group (Welling et al., 2016).

Although negative instructions have a negative influence on performance level, the influence of the regularly used negative instructions in practice on knee joint loading in relation to injury prevention has not been examined. The aim of this study was therefore to investigate whether positive (what to do) or negative (what not to do) instructions lead to optimized knee joint loads.

METHODS: First, frontal and sagittal plane videos of experts performing a 45° sidestep cut were created. The selection of these videos has been made based on a ranking of the five variables and visual inspection. The trial with the best rank of the POS trials and the best rank of the NEG trials was chosen (Table 1). Figure 1 shows part of the video of the POS and NEG condition respectively. The POS and NEG condition differ in a way of performing biomechanically optimal (lowest knee joint load) and suboptimal (highest knee joint load) respectively (Dempsey et al., 2007). Eighteen healthy male basketball players (mean age 15.5 ± 1.0 y, height 185.0 ± 6.8 cm, mass 69.2 ± 9.6 kg) participated in this study.

Then, sixteen reflective markers of 14 mm in diameter according to the Vicon Plug-in-Gait lower body model (Vicon Motion Systems, INC., Centennial, CO) were placed. Five additional trunk markers on the sternum, clavicle, C7, T10 and right scapula were attached.

Subjects used a 5m approach run followed by a 1-foot landing on the force plate and a 45° change in direction followed by running through a gate 5m away from the force plates. All subjects were left limb dominant (i.e. the leg they prefer pushing off and landing with). The general instruction was provided: ’run towards the force plate and after making the turn, you have to run through the gate’ for all conditions. First, subjects conducted three baseline (BASE) trials. Then, two randomly experimental conditions followed, each ten trials. POS and NEG video instructions were watched by the subjects every 3rd, 6th and 9th trial along with the following instruction ‘please have a look at the entire movement of the expert when making the turn and try to imitate the expert to the best of your ability’.

Table 1: Values of variables corresponding to the expert videos

	Expert 170-184 cm		Expert 185-200 cm	
	Positive	Negative	Positive	Negative
Knee flexion angle (º)	-31.8	-27.9	-55.3	-36.6
Knee flexion range of motion (º)	-3.3	-10.7	-2.3	-3.6
Knee extension (+)/flexion(-) moment (Nm/kg)	0.21	-3.58	-0.69	0.16
Knee adduction (+)/abduction (-) moment (Nm/kg)	1.01	-1.07	0.10	0.35
Vertical ground reaction force (N/kg)	22.02	23.14	12.66	14.40

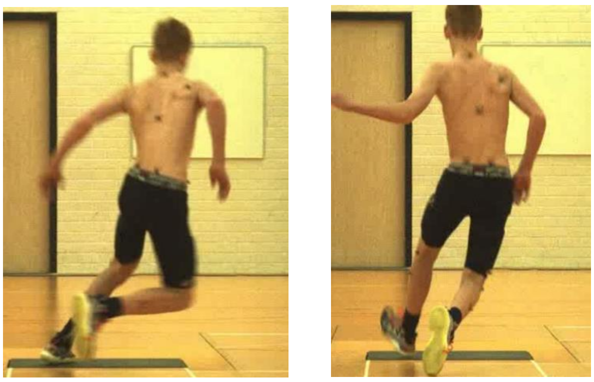

Figure 1: POS (left, performing the movement ‘well’) and NEG (right, performing the movement ‘badly’) condition of an expert performing the side-step cut. Note the different foot placements, torso leanings and sagittal knee angles.

Kinetic and kinematic data were captured using a 100 Hz eight camera motion analysis system (Vicon Motion Systems, INC., Centennial, CO, USA), Vicon Nexus Software (version 2.7.1 Motions Systems, INC., Centennial, CO, USA) and two 1000 Hz Bertec force plates (Bertec Corporation Columbus, OH, USA). Two 50 Hz Basler video cameras (cameras with a 25-mm and 9-mm C-mount lens Basler Inc., Exton, PA, USA) were used to collect expert videos.

Primary outcome variables were initial contact sagittal knee angle and moment and knee frontal plane moment. Moments were expressed as external moments normalized to body weight. A customized MATLAB script 9.6 (The MathWorks Inc., Natick, MA, USA) was used to compute variables of the tested leg. A MANOVA was conducted for each subject individually to determine differences between groups and conditions. Condition was used as within subject factor (BASE, POS and NEG), group as between subject factor (subject and expert) and three dependent variables (initial contact sagittal knee angle and moment and knee frontal plane moment). Post-hoc Bonferroni corrections were made to investigate the differences between the within factors. Significance was set at $\alpha<.05$.

RESULTS: In the POS condition, subjects were able to significantly increase knee flexion angle and decrease knee adduction and extension moment compared to BASE. The POS condition of subjects did not significantly differ from the POS experts for any variables, despite a significant decrease of knee abduction moment in 33% of the cases.

In the NEG condition, a significantly decreased knee flexion angle, knee extension moment and knee adduction moment were found compared to BASE. The subjects showed a significantly greater knee flexion angle and smaller knee extension moment compared to the expert. Every subject showed a significantly smaller knee frontal plane moment compared to the NEG expert. Table 2 shows the changes between and within subjects. Figure 2 displays within and between significant differences of one representative subject for knee flexion angle.

Table 2: Frequency table of changes between and within subjects for different variables

		Between (*n*=18) POS vs. EXP POS	NEG vs. EXP NEG	Within (*n*=17) POS vs. BASE	NEG vs. BASE
Knee flexion angle	Increase	1	8	6	0
	Decrease	1	1	1	6
	No difference	16	9	10	11
Sagittal knee moment	Increase extension	0	2	1	5
	Decrease extension	0	6	6	8
	Increase flexion	0	0	1	0
	Decrease flexion	4	1	1	0
	No difference	14	8	8	4
Frontal knee moment	Increase	3	0	2	5
	Decrease	6	18	7	8
	No difference	9	0	8	4

A significant increase or decrease in POS or NEG compared to EXP (POS or NEG) or BASE

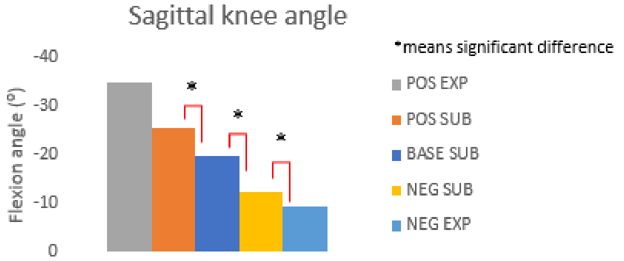

Figure 2: Knee flexion angles of a representative subject performing the POS, NEG and BASE conditions compared to the expert.

DISCUSSION: The purpose of this study was to investigate the effects of positive and negative video instructions on knee joint loading. The main finding of this study is that subjects were able to imitate movements through observational learning without giving any explicit instruction. This was especially the case in the POS condition where knee joint loading decreased. In the POS condition, subjects were able to reduce knee joint loading compared to BASE. This is in line with previous research where expert videos were used to improve landing technique without decreasing performance (Welling et al., 2016). However, the decreased external extension moment in the POS, was not exactly in line with the increase of the sagittal knee flexion angle. A small external knee flexion moment caused by the ground reaction force requires a relatively small counterbalanced internal extension moment created by low level of quadriceps activation. Therefore, it was expected that an increased knee flexion angle will go hand in hand with an increased external knee flexion moment.

Subjects did decrease knee flexion angle, extension and adduction moment in the NEG condition compared to BASE, which may increase knee joint loading. The significant differences of knee flexion angle and moment between subjects and experts in the NEG condition suggest that subjects were not able to completely copy the movements of the experts. Furthermore, the smaller frontal knee moments found in all subjects compared to experts could be explained by an unconstrained mechanism restrained the body to completely copy the unfavourable movement of the expert, to protect themselves. The differences between the NEG condition and BASE suggest that subjects were also able to, to some extent, imitate movements with increased knee joint loading. Further analysis of the data will provide more insight in magnitude of the differences and changes of the whole group. Negative effects in performance of negatively phrased verbal instructions were already found (Bakker et al., 2006; de la Peña et al., 2008). Current study suggest that negative visual instructions may also increase the knee joint loading and results in suboptimal performance. Coaches and trainers should be aware that instructions or demonstrations of exercises should be mainly performed in an optimal biomechanical (i.e. positive) way to promote the best learning possibilities. Furthermore, negatively performed instructions or demonstrations could increase the risk of performing exercises with increasing knee joint loading.

CONCLUSION: Subjects were able to perform sidestep cutting with reduced knee joint loading in the positive condition. Implications for this are the applicability of visual motor learning by providing an incentive to the athlete to optimize knee joint loads. To some extent, they were also able to imitate the movements of the negative condition (with suboptimal knee joint loading) which should not be ignored when teaching athletes motor skills. Coaches are therefore advised to use experienced, trained athletes to demonstrate exercises and promote optimal learning possibilities.

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