St Mary's University Twickenham, London

Effects Of Different Attentional Foci On Performance, Kinetic And Kinematic Variables In Countermovement Jumps And Drop Jumps

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Daniel Kadlec

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Effects of different attentional foci on performance, kinetic and kinematic variables in countermovement jumps and drop jumps

by

Daniel Kadlec

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1st supervisor
Daniel J. Cleather

2nd supervisor
Emily J. Cushion

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ABSTRACT

The aim of this study was to determine how focusing attention during countermovement jumps (CMJ) and drop jumps (DJ) affects kinetic, kinematic and performance variables. Nineteen well-trained athletes performed 3 CMJ and 3 DJ under a controlled condition (CON), internal focus condition (INT) and external focus condition (EXT) in a counterbalanced order. Changes in jump height, peak force and impulse were analysed between the conditions. Contact time and reactive strength index (RSI) were analysed for the DJ. In the CMJ the temporal occurrence of the lowest ground reaction force (F_{min}) and its interval until take off (t_{Fmin}) were calculated. Joint moments and peak flexion angles were calculated in the ankle, knee and hip. In the CMJ the EXT elicited the best performance (49.0 ± 3.8 cm), which was significantly ($p<0.05$) better than the CON (46.4 ± 4.0 cm) and the INT (45.4 ± 4.1 cm). A significant ($p<0.05$) reduction in peak hip flexion, peak knee flexion and t_{Fmin} was observed in the INT compared to the EXT and CON. Further $_{Fmin}$ was significantly reduced in the EXT compared to the other groups. In the DJ the EXT (37.4 ± 4.7 cm) significantly improved ($p<0.05$) jump height compared to CON (34.4 ± 5.3 cm) and INT (34.9 ±5.3 cm). No other kinematic and kinematic variable differed significantly between the conditions in the DJ. Different instructions induced different performance outcomes and movement coordination. The current results demonstrate, that an EXT immediately improved vertical jump performance in well-trained athletes compared to other instructions.

Key Words: instructions, plyometrics, movement pattern, jump height,

INTRODUCTION

Due to the limited time for training it is essential to choose training methods that are likely to elicit maximal adaptations for a given amount of time. Increasing physical performance in already trained athletes demands often a lot of time and energy. However, not only the type of training can have a substantial impact on the training response, but also the instructions provided by the coach can influence the execution of an exercise and subsequently elicit a different adaptive response (8, 21, 37, 52). Different verbal instructions can manipulate the athletes' focus of attention. The focus of attention can be either directed internally or externally. An internal focus (INT) means instructing the athlete to think about specific body parts, joints or certain movements during a given task. An external focus (EXT) is defined as directing the athlete's attention towards the effect of the movement during the execution on the environment (65, 68). Although the instructions can differ just in a couple of words, evidence from the last 15 years in motor behaviour research clearly demonstrated that attaining EXT compared to an INT results in superior performance outcome independent of the task (65). It has been shown that EXT significantly enhances balancing performance (65) and accuracy tasks, like hitting golf balls (69) and throwing darts (37). Furthermore, activities like vertical jumping (66, 67), horizontal jumping (46, 48, 62, 64), speed and agility (23, 45, 47, 49) as well as endurance (53) tasks produced significantly superior results when subjects were instructed to attain an EXT.

The constrained action hypothesis (CAH) is commonly used to explain the differences in performance measures and motor skills when using an external focus compared to an internal or no specific focus (70). The CAH suggests that an INT focus constrains the automatic motor control process and causes a deterioration in the execution of coordinated and efficient movements. However, focusing consciously on the movement outcome (EXT) allows the motor control system to naturally regulate and organise the movement in a superior manner. It has been demonstrated, that an EXT promotes a more efficient and effective motor coordination relative to an INT (37, 56, 74). In addition, an optimised movement pattern, which improved performance outcomes, has been reported in response to an EXT compared to an INT (36, 42).

Previous research has showed that different instructions influence CMJ (66, 67) and DJ (16, 30) performance variables. However, there is little research that has shown how different foci affect the kinetics and kinematics throughout the motion of a CMJ (29, 66) and a DJ (16, 30), leading to different performance outcomes. Several studies reported increased jump performances with an EXT compared to an INT, while producing similar amounts of peak ground reaction force (GRF) (12, 29, 37, 64). The authors argued that an altered movement coordination caused the significant difference in performance outcome despite almost identical peak GRF between each condition. Further, Ducharme et al. (12) showed that the projection angle during a standing long jump was more efficient in an EXT compared to an INT, suggesting an EXT optimises subconsciously movement coordination. Others found, that higher jump performance was related to greater joint moment production at the ankle, knee and hip independent of the instruction (55). Wulf et al. (71) reported an increased jump height, impulse production and lower extremity joint moments when adopting an EXT during a CMJ. The authors suggested, that the EXT lead to a greater jump height caused by a greater force production. In addition, Makaruk et al. (37) reported a significant increase in GRF production and jump height in the CMJ after a training period with an EXT compared to an INT and a control condition (CON). Further, the EXT group increased their maximal knee flexion during the CMJ, indicating a change in movement coordination. Therefore, higher CMJ performance can be achieved by generating more impulse in the same amount of time or by adopting a more efficient motor pattern or a combination of both. Both have been linked with adopting an EXT during the vertical jump tasks (65). However, little research has been done on the effect of different foci in well-trained athletes. As well-training athletes generally posse superior physical abilities, it is suitable to assume, that they already use subconsciously an optimal focus during different tasks and/or have an optimal movement coordination. Previous studies have reported inconsistent findings between attentional focus instructions and performance outcomes in trained athletes. An EXT improved performance in shot-putting (38), running (23), swimming (17) and punching (19). However, there is evidence, that an CON elicited superior performance outcomes compared to an EXT in balancing (65) and sprinting (47) in well-trained athletes. Further, Porter et al. (48) showed, that an EXT significantly increased broad jump distance compared to a CON and an INT in well-trained athletes. However, no kinetic or kinematic analysis was conducted to explain those results. Therefore, the level of the athlete may be a relevant variable, when choosing the optimal instruction to maximise performance. Whether a shift in attentional focus can improve performance and affect movement coordination in well-training athletes during vertical jump tasks needs to be investigated.

Further, it hasn't been shown which specific instruction leads to an enhanced reactive ability as measured in the DJ. The DJ is commonly used to assess the reactive ability of an athlete. The aim in the DJ is to minimise ground contact time (GCT) and increase jump height simultaneously. DJ height has been shown to increase when the subjects produced a higher force during the GCT (16). Likewise, a higher GRF was reported with decreased GCT (30, 61). Previous studies reported, that DJ performance has a positive relationship with maximum velocity sprinting speed (27). In order to quantify the reactive ability of an athlete the reactive strength index (RSI) has been developed (14). The RSI is calculated from the jump height and GCT (m/s). It has been shown that different instructions can affect DJ performance immediately (30, 72). However, the instructions were either to minimise GCT or to increase jump height or an INT. As a consequence, both GCT and flight time increased or decreased simultaneously (30, 72). In addition, it was reported, that the type of instruction changed peak flexion angles of ankle, knee and hip (16, 30). Further, it has been shown that after a training period with an EXT DJ height and GRF increased but so did GCT and maximal knee flexion, suggesting an altered movement strategy (29). Consequently, an optimal instruction hasn't been yet established in order to increase DJ performance. Providing an instruction with the focus to minimise GCT and increase jump height simultaneously might induce a superior DJ performance outcome.

As previously described and according to the CAH, a simple change in words can alter the performance outcomes in vertical jump tasks by changing kinematic and kinetic variables. Therefore, knowing exactly how specific instructions affect the execution of a given exercise and which specific instructions are best suited to elicit immediately the desired outcomes is essential for the practitioner. Knowing the exact mechanism for different instructions can help to optimise training. Getting a more in depth understanding about how to instruct athletes to produce maximal performance is essential to deliver the best content possible within each session for the practitioner and the scientific community. The purpose of the current study is to explore the mechanism of the CAH by determining the underlying kinematic and kinetic causes that affect CMJ and DJ performance in well trained athletes in response to 3 different instructions. It was hypothesised that an EXT would increase CMJ and DJ performance with a concomitant increase in joint moments and impulse production. A further aim was to determine the difference in joint angles throughout the motion between the 3 conditions to determine alterations in the movement coordination. It was hypothesised that an EXT would lead to greater flexion angles in the CMJ and smaller flexion angles in the DJ in one or more joints, respectively, in order to maximise performance.

METHODS

Experimental approach to the problem

This study was designed to determine the influence of different instructions on kinematic and kinetic variables during a CMJ and a DJ. Each subject completed three CMJ and DJ, respectively, under three different instructions. Dependent variables included for the CMJ were centre of mass (COM) displacement (cm), peak force (N), impulse (Ns) and joint moments (Nm). Further, the minimum force (F_{min}) and the time interval to take-off (t_{Fmin}) were analysed (Figure 1). Dependent variables for the DJ were GCT (s), jump height (m), peak force (N), impulse and reactive strength index (RSI). Peak flexion angles of the ankle, knee and hip were analysed for each condition in the CMJ and DJ (Figure 2). Three experimental conditions were used as independent variables, a CON, INT condition and EXT condition. Kinematic and kinetic data were recorded with a portable force plate and a high speed camera. The data of all jumps were statistically compared across the conditions to test the hypothesis.

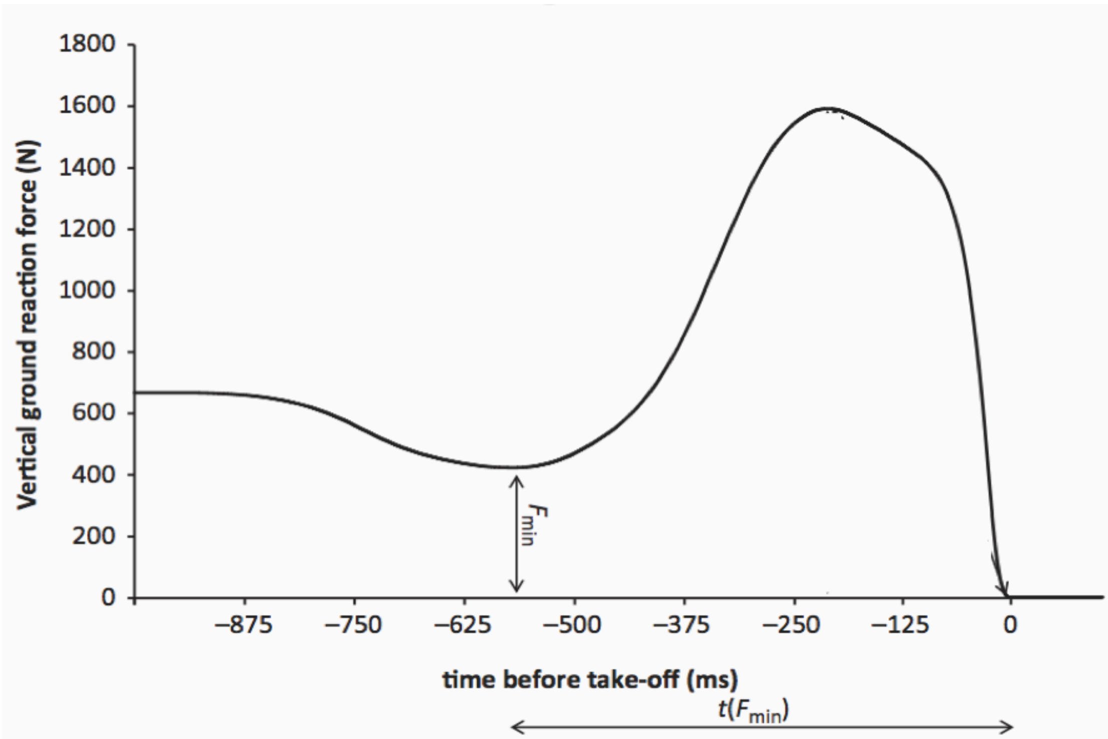

Figure 1. An exemplary vertical GRF during a CMJ. The magnitudes and temporal occurrences of the minimum peaks before the take-off (F_{min} and t_{Fmin}) were analysed for each trial.

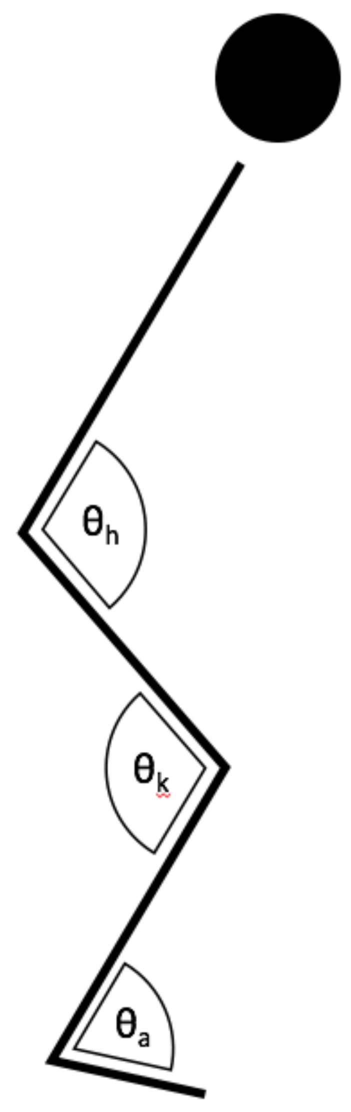

Figure 2. Joint angles derived from the linked-segment model of the body during in the CMJ and DJ for all conditions. θ_h = hip joint, θ_k = knee joint, θ_a = ankle joint.

Subjects

Healthy male subjects (n = 19, age = 23 ± 4 years, height = 186.9 ± 6.8 cm, weight = 86.2 ± 7.4 kg) were recruited from an elite male handball team. Subjects were familiar with the CMJ and DJ. Only subjects with at least one year experience with resistance training and free from musculoskeletal injuries within the past six months that could affect their current jumping performance were tested. Subjects were given an information sheet, verbally instructed about the testing procedure and were asked to sign a consent form before the investigation. However, all subjects were unaware of the exact hypothesis in order to avoid any influence on the execution of the jumps. Ethical approval was given by the ethical review board of St Mary's University.

Procedure

After a standardised warm up protocol (Figure 3) each subject was instructed with all necessary information about the upcoming investigation. Markers for the kinematic data were attached on bony landmarks of the right distal end of the foot (metatarsal head), ankle (lateral malleolus), knee (lateral tibial plateau), hip (greater trochanter) and shoulder (acromioclavicular joint). All jumps were executed with hands on hips. The rest periods between the jumps were self-selected. This has been shown to be a reliable method for trained subjects (18) in order to ensure maximal performance outcomes. After stepping with each foot on one each force plate respectively, the subject was instructed to stand motionless for 3 seconds to determine body weight before each jump. Then performed 3 single CMJ with self-selected depth and self-selected rest between each jump to determine the baseline value with the instruction "jump to the best of your abilities while maintaining hands on hips". After a self-selected rest of 3-5 minutes the subject performed 3 drop jumps from a 40 cm box with the instruction "jump to the best of your abilities while maintaining hands on hips". The subject was instructed to step off the box and land with each foot on one force plate, which were placed 15 cm in front of the box. The subjects were assigned in a counterbalanced order to one of two experimental groups (INT or EXT) and repeated the same procedure but with another instruction. Then the subjects were assigned to the other experimental group, where he repeated the same jumps but with a different instruction. Each participant performed in total 9 CMJ and 9 DJ. The EXT instruction was "touch the hanging ball over your head while maintaining hands on hips" for the CMJ and "jump and reach towards the hanging ball over your head while maintaining hands on hips" for the DJ. Only for the EXT a tennis ball was attached over the subjects' head hanging from the ceiling at sufficient height, that the participants were not able to touch it. This can be accounted as a distal EXT, which has been shown to lead to superior results compared to a proximal EXT, INT and CON (28, 48). The INT instruction for the CMJ was "extend your hip and knee as forcefully and fast as possible while maintaining hands on hips" and for the DJ "When you touch the ground, immediately extend your hip and knee as forcefully and fast as possible while maintaining hands on hips". Every subject received the respective instruction before the execution of each single jump to increase the likelihood to retain the specific instruction. The testing procedure took roughly 20-25 minutes per subject. All subjects were instructed to wear spandex shorts. Subjects were not informed about their jump height during the test. The testing took place in a private gym where the participants usually conducted their strength training. All tests were conducted during the competitive period of each subjects from March to April and before their respective mandatory strength session.

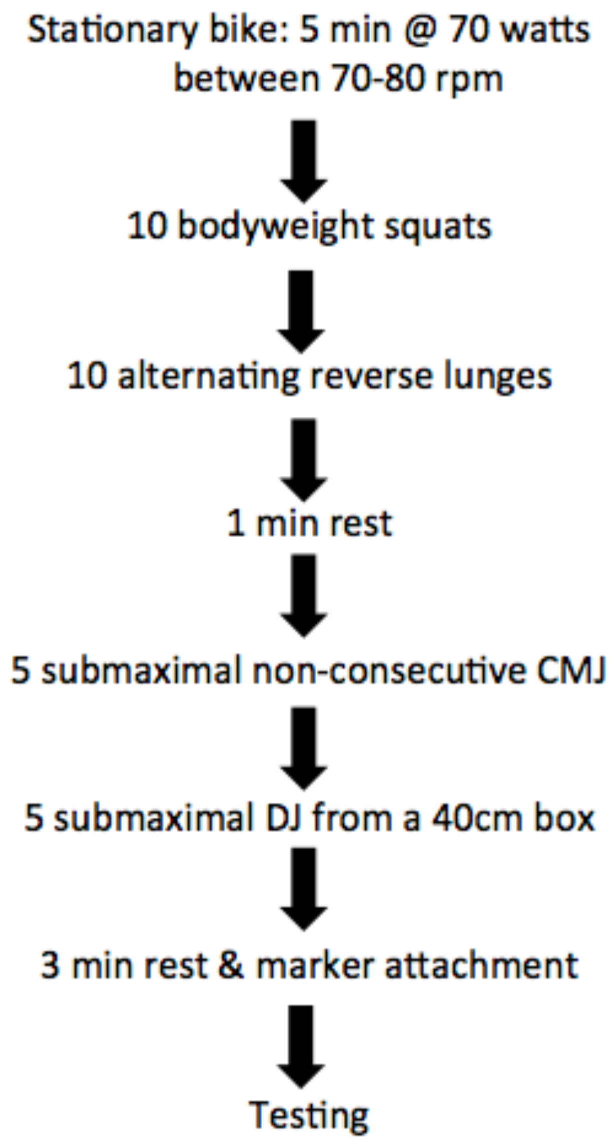

Figure 3. Standardised warm up protocol prior to testing.

Instrumentation

GRF was recorded with two portable force plates (PASPORT Force Platform PS-2141, 350mm x 350mm, PASCO, Roseville California, USA) sampling at 1000 Hz. Data from both force plates was summed for further calculation. Kinematic data was collected with a high speed video camera (IPhone 6s, iOS 9.3.1, Apple Inc., Cupertino California, USA) sampling at 240 Hz. The camera was set up perpendicular to the right side of the subject and calibrated with two poles of known height (1.20 m) placed 0.5 m apart in the centre of the field of view.

The centre of the lens was at 0.9 m of height. A trigger switch was used to synchronise kinetic and kinematic data with a synchronisation unit. Kinetic and kinematic data were digitally filtered using a low-pass fourth order Butterworth filter with a 10 Hz cut off frequency. CMJ jump height was calculated using the impulse-momentum method from the GRF data obtained from the force plates (24). DJ height was calculated by the flight time duration ($jump\ height = 0.5*g*(t/2)^2$, t is the flight time and g the gravitational acceleration). GRF less than 5 N was considered as flight time. Impulse was determined by using the trapezium rule to calculate the are under the force-time curve during the CMJ and DJ, respectively. In order to calculate net joint moments of the ankle, knee and hip, an inverse dynamics analysis (IDA) was used. A 2D, rigid, linked, four segment model (foot, leg, thigh, trunk) was used (Figure 4). A standard IDA was employed combining kinematic coordinates and GRF data as reported elsewhere (63). Segmental inertial characteristics were calculated from given anthropometric data (63). The following steps were used to calculate joint moments; i) the kinematic data from each marker were transformed into coordinates with an appropriate software (Kinovea, 0.8.15, France); ii) force and moment at the distal end of the foot segment were calculated from the force plate data; iii) according to the Newton-Euler equation of motion moments and forces were calculated for each joint from distal to proximal.

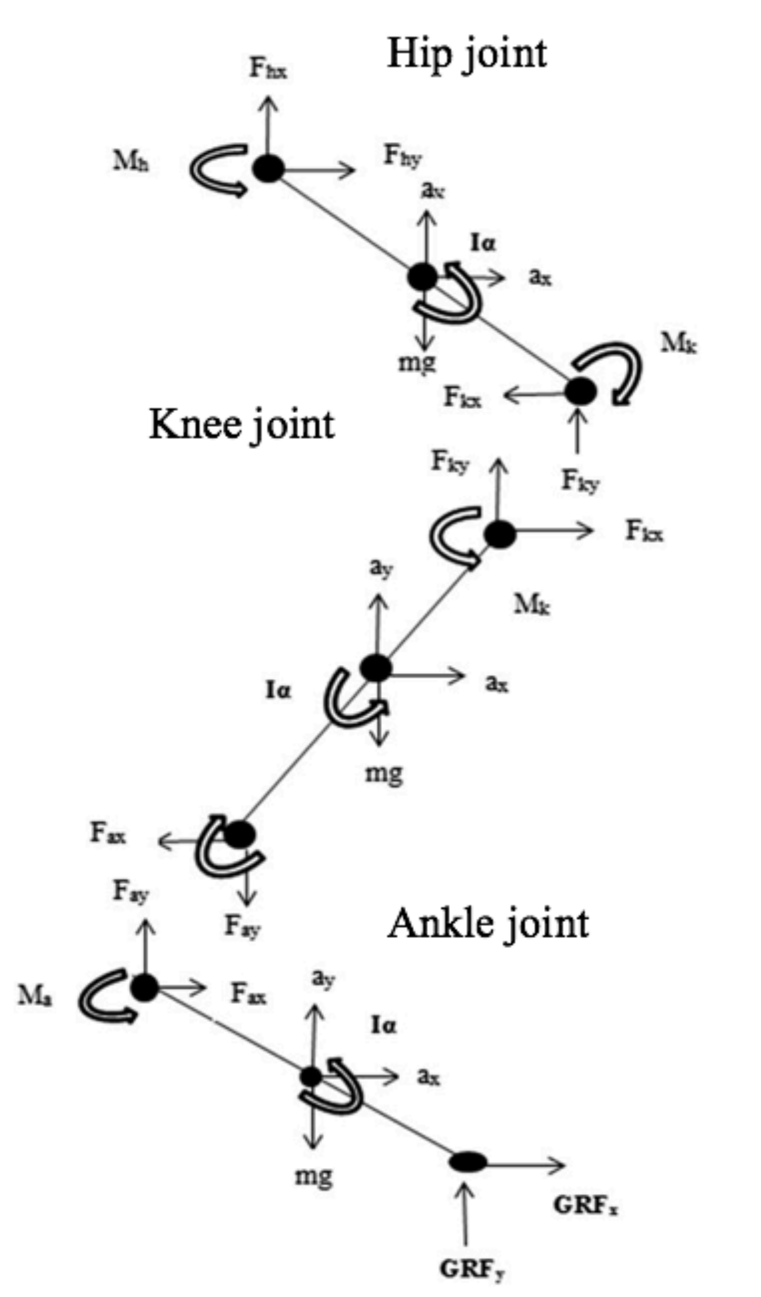

Figure 4. Free body diagram for IDA. Adapted from Cushion et al. (10)

Statistical analyses

For all analyses the mean values of the two best CMJ and two best DJ under each conditions for each subject was used. Means and *SDs* were calculated using standard statistical methods. Normality of all variables was tested using Kolmogorov-Smirnov test procedure. A repeated measures analysis of variance (ANOVA) was used to compare the dependent variables between the experimental conditions. Bonferroni post hoc analyses was used to identify statistical significance when ANOVA detected significant results. In order to determine the magnitude of observed significant findings effect size (ES) was calculated using partial eta squared values (η^2: small effect < 0.01; medium effect = 0.06; large effect > 0.14). A Pearson product-moment correlation was calculated to determine which kinematic variable correlates most highly with CMJ height. Interpreting correlations, following guidelines are established: trivial, $r < 0.10$; small, $r = 0.10$-0.30; moderate, $r = 0.30$-0.50; large, $r = 0.50$-0.70; very large, $r = 0.70$-0.90; and nearly perfect, $r > 0.90$. A Fisher-Yates test was used to determine, whether there is significant difference between the expected frequencies and the observed frequencies in the best performance induced by the 3 different conditions. Statistical significance was accepted at $p < 0.05$. The Statistical Package for Social Science (version 22.0; SPSS, Inc., Chicago, IL, USA) was used for all analyses.

RESULTS

CMJ

Figure 5 shows that jump heights differed significantly between the conditions (Wilks' Lambda = .38, $F(2, 17) = 13,81$, $p \leq .01$, $\eta2 =.62$). Bonferroni post-hoc comparisons indicated that each pairwise comparison was significant, $p \leq .01$. EXT (49.0 ± 3.9 cm) was significantly higher than CON (46.4 ± 4.0 cm) and INT (45.3 ± 4.2 cm). Significant differences were found in F_{min} (Wilks' Lambda = .43, $F(2, 17) = 11.23$, $p \leq .01$, $\eta2 = .57$) and t_{Fmin} (Wilks' Lambda = .67, $F(2, 17) = 4.12$, $p \leq .05$, $\eta2 =.33$) (Figure 5). There were significant ($p \leq .01$) differences in F_{min} between the EXT (211.9 ± 140.8 N) and both other conditions (CON: 366.6 ± 155.5 N, INT: 338.3 ± 169.3 N). t_{Fmin} differed significantly ($p \leq .05$) between the CON (627.1 ± 119.3 ms) and the INT (540.1 ± 105.2 ms). Kinetic data is presented in Table 1. Relative peak force demonstrated a significant effect between the conditions (Wilks' Lambda = .69, $F(2, 17) = 3.71$, $p \leq .05$, $\eta2 = .30$). There was a significant difference between the INT and both other conditions ($p \leq .05$). Kinematic data are presented in Table 2 for all conditions. A significant effect was observed for the knee (Wilks' Lambda = .65, $F(2, 17) = 4.47$, $p \leq .05$, $\eta2 = .34$) and the hip (Wilks' Lambda = .56, $F(2, 17) = 6.77$, $p \leq .01$, $\eta2 = .44$) between the conditions. Peak knee flexion and peak hip flexion angles were significantly smaller for the INT compared to the other conditions ($p \leq .05$). Relative peak joint moments for all conditions are presented in Table 1. No significant differences were observed in any values between the conditions. A significant ($p \leq .05$) negative correlation ($r = - 0.432$) was found between peak hip flexion and jump height independent of the condition (Table 3).

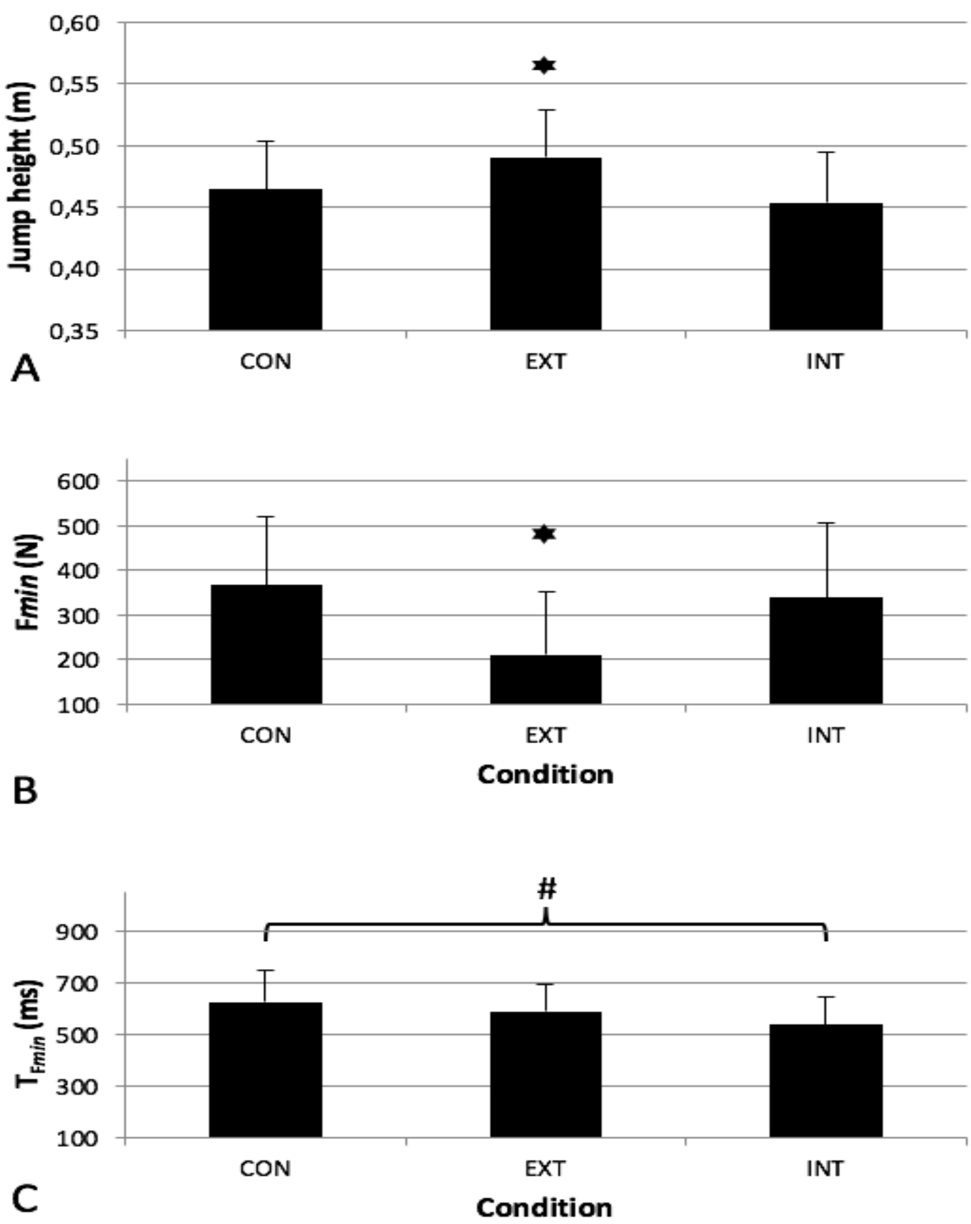

Figure 5. Results from jump height (A), F_{min} (B) and t_{Fmin} (C) between the tested conditions (CON, EXT, INT) in the CMJ. Data are shown as mean ± standard deviation. * denotes a significant difference between the EXT compared to the other groups at $p \leq 0.01$. # denotes a significant difference between the CON and the INT condition at $p \leq 0.05$.

Table 1. Kinetic data (mean ± *SD*) from the CMJ and DJ between all conditions

	CMJ			DJ		
	CON	EXT	INT	CON	EXT	INT
Relative Peak Force (N•kg)	2.4 ± 0.3	2.4 ± 0.3	2.6 ± 0.4 •	4.9 ± 1.0	4.9 ± 1.5	4.9 ± 1.4
Impulse (Ns)	236.9 ± 23.8	241.7 ± 21.7	233.5 ± 24.4	566.3 ± 87.9	572.1 ± 102.3	571.8 ± 100.6
Relative NJM ankle (Nm/kg)	-3.6 ± 0.4	-3.5 ± 0.5	-3.7 ± 0.7	-7.3 ± 1.9	-7.0 ± 1.5	-6.6 ± 21.8
Relative NJM knee (Nm/kg)	2.6 ± 1.0	2.7 ± 0.7	2.9 ± 0.7	3.8 ± 1.2	3.5 ± 1.4	4.1 ± 1.3
Relative NJM hip (Nm/kg)	-4.9 ± 0.7	-5.0 ± 0.7	-4.7 ± 0.4	-15.3 ± 5.1	-17.3 ± 10.5	-22.2 ± 11.7

• = significant difference between INT and both other conditions, $p \leq 0.05$.

Table 2. Kinematic data (mean ± SD) from the CMJ and DJ between all conditions

	CMJ			DJ		
	CON	EXT	INT	CON	EXT	INT
Peak flexion ankle (°)	83.3 ± 4.9	82.5 ± 3.8	84.4 ± 4.4	88.1 ± 5.7	86.4 ± 5.8	87.1 ± 5.5
Peak flexion knee (°)	94.3 ± 7.5	93.8 ± 7.4	99.6 ± 8.6 •	119.1 ± 9.2	116.1 ± 10.7	115.7 ± 9.5
Peak flexion hip (°)	67.5 ± 13.7	67.5 ± 13.5	78.8 ± 15.7 •	130.4 ± 14.3	125.9 ± 15.4	125.4 ± 14.6

• = significant difference between INT and both other conditions, $p \leq 0.05$.

Table 3. Relationship between CMJ height and joint angles. (*r* values)			
	Ankle	Knee	Hip
CON	0.205	-0.032	-0.386
EXT	0. 212	-0. 027	-0. 407
INT	0.439	-0.046	-0.390
Combined	0.207	-0.115	-0.432*

* = significant correlation, $p \leq 0.05$.

DJ

Spatiotemporal variables are for all conditions are presented in Figure 6. Significant main effect was detected for jump height (Wilks' Lambda = .52, $F(2, 17) = 7.79$, $p \leq .01$, $\eta2 = .48$) between the conditions. There was a significant difference between the EXT (37.3 ± 4.7 cm) compared to the CON (34.2 ± 5.4 cm) and INT (34.8 ± 5.4 cm) group ($p \leq .01$). No significant differences were observed in GCT (CON: 0.227 ± 0.04 s; EXT: 0.24 ± 0.061 s; INT: 0.25 ± 0.05 s) and RSI (CON: 1.558 ± 0.355; EXT: 1.675 ± 0.505; INT: 1.498 ± 0.434) between the conditions. Kinetic data are shown in Table 1. No significant differences in any values between the conditions were observed. Kinematic data are presented in Table 2. No significant differences were observed between the conditions.

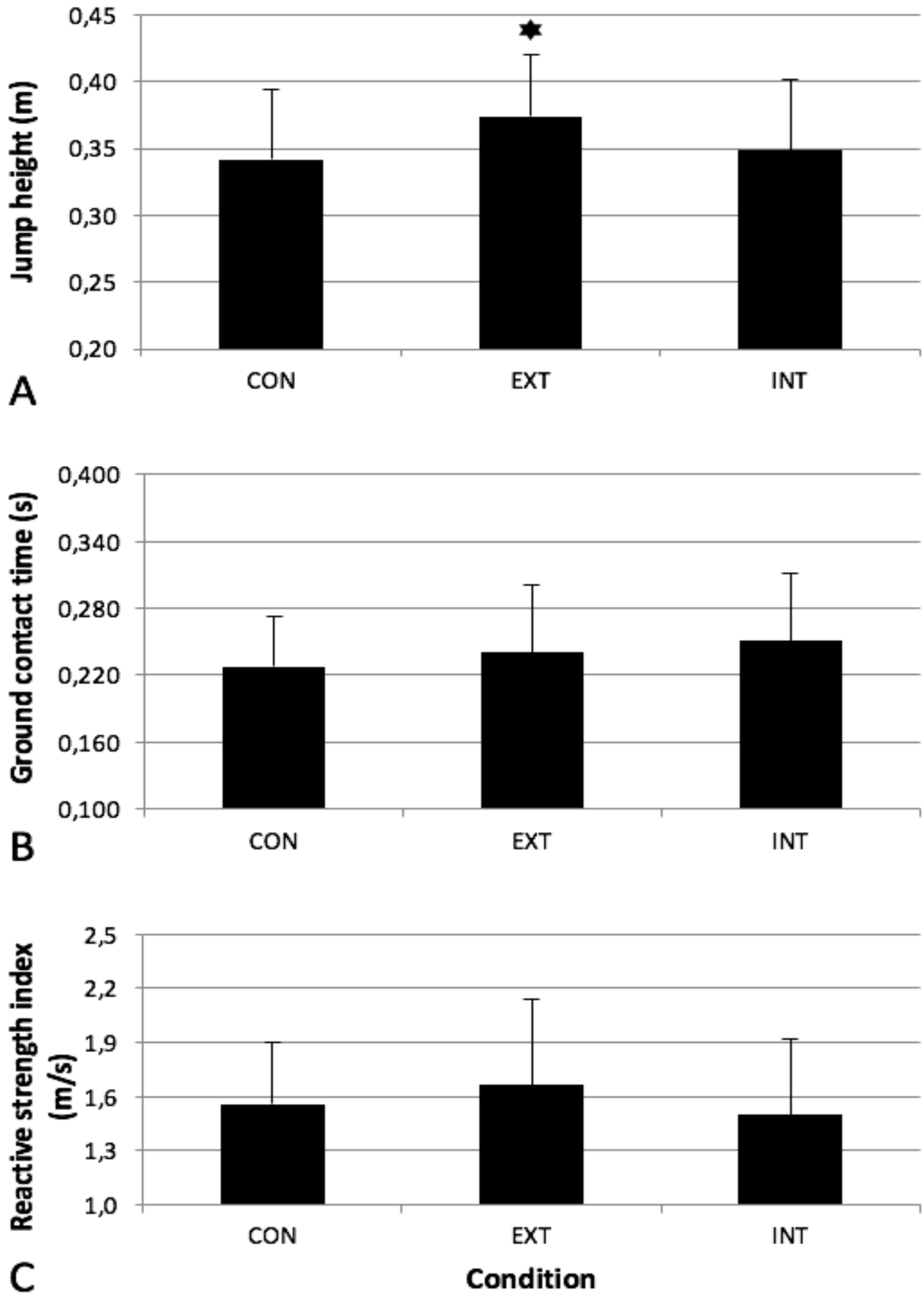

Figure 6. Results from jump height (A), ground contact time (B) and reactive strength index (C) between the tested conditions (CON, EXT, INT) in the DJ. Data are shown as mean ± standard deviation. * denotes a significant difference between the EXT compared to the other groups at $p \leq 0.01$.

Best performances

Best performances in the CMJ were significantly overrepresented in the EXT (χ^2 (2, 17) = 14.63, $p \leq .01$). No association was observed between the conditions and best performances in the DJ.

Table 4. Number of best performances between the conditions

	CMJ			DJ		
	Jump height (m)			RSI (m/s)		
Subject	CON	EXT	INT	CON	EXT	INT
Total	4	14 *	1	7	9	3

* = significant difference between EXT and both other conditions, $p \leq 0.01$.

DISCUSSION

The purpose of the present study was to examine the underlying causes why different foci induce different performance outcomes in CMJ and DJ. The results of the current study partly confirm our hypothesis. The EXT increased CMJ and DJ performance. However, kinetic and kinematic differences were only detected in the CMJ between the conditions.

According to the hypothesis, an EXT led to a higher CMJ performance than the CON or INT. These results are in accordance with other research, that showed superior performance outcomes compared to a CON or INT in a variety of tasks (65). In line with previous studies CMJ performance can be immediately increased with an EXT (66, 67). In the current study we found a significant difference of 4.6 cm between the EXT and INT. Previous studies reported similar increases of up to 3.3 cm with an EXT compared to an INT (66, 67). However, those studies used a Vertec device in order to determine jump height. Subjects were instructed to touch the horizontal rungs during the jump. This is regarded as an EXT, but it provides additional tactile information during the movement. This can be classified as feedback. Adding appropriate feedback to a motor skill has been shown to increase performance (71). In the current study a tennis ball was attached over the subject's head in realistic but unreachable height. Therefore, tactile feedback was not possible in the current study. Consequently, the improvement in CMJ height can be attributed to the specific instructions given. Further, the EXT instruction in combination with the tennis ball over the subject's head in the current study can be considered as a distal EXT. Previous studies have established that providing a more distal EXT (e.g. "jump through the ceiling") compared to a proximal EXT (e.g. "explode off the ground") facilitates performances outcomes in a variety of tasks (4, 28, 48), if the distance of the distal EXT is within a realistic frame, otherwise performance deteriorates (62). However, this effect hasn't been shown in vertical jumps tasks. Further research is necessary to demonstrate if a distal EXT facilitates performance compared to a proximal EXT in the CMJ.

Contrary to the initial hypothesis, no significant changes were recorded in the joint moment production between the conditions in the CMJ, which is in contrast with other findings (66). The current joint moments were found to be inconsistent with previous research (34, 55, 58). The current ankle and knee moments of 3.5-3.7 N/Kg and 2.6-2.9 N/Kg respectively are in relation with others, who found values of 2.8-3.2 N/Kg and 3.1-3.4 N/Kg for the respective joint (9, 55). However, the hip joint moments were found to be inconsistent with previous results. Relative hip joint moments up to 5 Nm/Kg are very high. Previous research reported relative hip joint moments of 1.5 to 3.5 Nm/Kg in similar tasks (34, 67). However, it could be theorised, that in order to play handball on a national level it is necessary to display such values. Thus a more hip dominant jumping movement pattern could be a "handball-specific" prerequisite. All of the current subjects displayed in both jump types higher hip then knee moments, thus can be classified as hip dominant. It has been shown that different athletes have either a knee dominant (generating greater amounts of knee moment), hip dominant (generating greater amounts of hip moment) or balanced movement pattern during vertical jumping tasks (9, 51). Further, the dominant direction of locomotion has been suggested to determine the dominant joint to produce peak moments (9). Further, higher hip:knee moments were associated with increased vertical jump performance (34) and side step distance (24), both essential tasks in handball. However, this assumption needs further investigation to clarify if handball players have joint dominant movement pattern.

The significant negative correlation (Table 3) between hip flexion and combined CMJ height suggests, that in order to achieve a maximal performance, proper hip flexion during the countermovement is essential. However, when the correlation was calculated for each condition, the significance disappeared. This indicates, that each condition induced a different movement pattern. This is in accordance with other findings, which showed different movement pattern for the same task (15, 50). Subjects in the INT condition displayed a mean of 11° less peak hip flexion and 5-6° less peak knee flexion during the CMJ compared to the other conditions. A reduction in hip flexion is associated with a more upright trunk position. Therefore, less potential to generate force with the hip extensor muscle group. In order to maintain performance outcomes other muscle groups need to compensate this reduced hip flexion. In such cases, it has been demonstrated knee extensor activity increases during the CMJ (33, 57). Indeed, it could be suggested, that the highest joint moments at the knee were displayed in the INT condition in the current study. Although not significant, the EXT displayed a greater hip moment then the INT (Table 1). This is in line with other research, demonstrating similar joint moments with restricted trunk inclination (33, 57). Avoiding high hip moments due to the more upright position of the trunk during a CMJ, decreases the potential to train the hip extensors properly. Further, higher knee moments are associated with an increased quadriceps recruitment (11). Both has been linked to increased intraarticular forces (22, 73), which are related to different injury types (13, 40). This would suggest to avoid an INT during CMJ from an injury prevention and performance enhancement view (20). Further investigation in this area is needed to fully understand the internal mechanics in response to different instructions and how they affect performance outcomes.

Despite no significant changes in the joint moment production between the conditions in the CMJ, the EXT altered the movement coordination. Based on the GRF data, it can be suggested, that the experimental condition influenced the movement coordination by altering F_{min} and t_{Fmin} (Figures 5). Subjects in the INT displayed high F_{min} and low t_{Fmin}, which indicated, that they obeyed to the specific instruction by "extending your legs and hips as fast and forceful as possible". This led subsequently to a shallower countermovement, as measured by the peak flexion angles (Table 2), and interfered with the regular flexion pattern.

Therefore, time to produce propulsive force was limited in the INT. Although peak force was significant higher in the INT compared to the other groups, jump height was reduced (Figure 5). This is in line with previous findings, which demonstrated that peak force contributes only trivially to CMJ height (41, 54), while others even reported a negative relationship (r = -.41) between peak force and jump height (32). Further, peak force has been shown to decrease, when the time to complete the propulsive part of the CMJ increases (5, 32), which is corresponding to the current findings. Therefore, higher peak GRF values were necessary to compensate for the short timeframe available in the INT condition. However, because force was applied over a shorter timeframe, impulse tended to be reduced in the INT compared to the other conditions (Table 1). Impulse is the product of force and time over which it is applied and has been shown to correlate (r = 0.92) with jump height (32). This is in accordance with our findings, that the EXT elicited the highest CMJ performance and the corresponding impulse was close to statistical significance (p = .079) compared to the INT. Generating high impulses is an essential strength quality and important for explosive movements (1). Therefore, it can be stated, that the specific INT used in this study impaired the natural movement coordination and deteriorated the performance compared to the EXT, which is in accordance with previous research (29, 65, 66) and the CAH. It is recommended to omit the INT and provide the EXT instruction used in the current study, if maximal performance is the goal.

The results of the DJ showed only a partly correspondence with the initial hypothesis. Only jump height improved significantly in the EXT (Figure 6). This is in line with previous research, demonstrating that an EXT combined with a visible overhead goal increased DJ height significantly in trained athletes (16). Others failed to report a significant increase in DJ height in the EXT compared to CON and a INT condition after a training period with different foci as independent variable (28). However, no overhead goal was incorporated during the DJ training. This suggests, that an EXT is only beneficial when adding a visible overhead goal within realistic heights in DJ in a trained population. Longitudinal research is needed to clarify if an EXT with an overhead goal increases DJ performances compared to other conditions.

GCT of 0.22-0.24 s were almost constant across the conditions and in line with previous research (2, 61). In the current study the CON tended to induce the shortest and the INT the longest GCT. Similar results were reported from others, who found the longest GCT in an INT (30) and the shortest GCT in a CON (37). These results suggest, that contrary to the CAH an EXT doesn't induce superior results in the DJ as measured by the contact time. Different types of instructions are more likely to reduce contact time as shown in previous research (30). Therefore, if the goal is to reduce contact time, different instructions should be provided then the one used in the current study.

The RSI is an effective tool in the practical setting as well in the literature to quantify DJ performance (31). The current results suggest, that the EXT condition induced higher RSI values compared to the other groups, which was close to statistical significance (p = .053). The INT tended to decreases RSI, which is in line with previous research (30). Therefore, an EXT was likely to elicit the most optimal ratio of jump height and ground contact time compared to the other conditions. These results are practical relevant, as it is impossible to quantify DJ performance without any equipment. However, knowing that an EXT tended to elicit a more favourable RSI compared to an INT is important for the practitioner to ensure best practise methods.

Kinetic parameter did not differ significantly between the conditions in the DJ. Relative peak force values are in line with other research, which reported GRF values of 5.23 N/kg (2) and

4.4 N/kg (25) from a similar box height. Using a smaller drop height has been shown to results in lower GRF of 2.9 N/kg (60) and 1.7 N/kg (16). GRFs have been shown to increase with drop height (25, 60). However, others reported (16), that a significant improvement in DJ height in an EXT group was independent of the peak vertical GRF applied to the ground during the contact phase in a female population, suggesting an important role to the movement coordination (6).

Further, the current study revealed, that joint peak flexion angles were constant across the conditions. Therefore, it can be suggested that the movement pattern was relative stable between the conditions. Knee joint angles were found to be inconsistent with previous findings (16, 30, 37). Peak knee flexion angles of 93-100° are in contrast to our findings of 115-120°. However, they have shown to have substantial longer GCT of 0.39-0.42 s compared to our results (Figure 6). Smaller peak flexion angles in the knees are essential for an effective DJ performance as they correspond with a smaller change in distance of the centre of mass during the contact phase. Skilled jumpers have previously been shown to display smaller peak flexion angles in the knee and ankle, which is in correspondences with a shorter contact time compared to less skilled jumpers (59). Greater joint flexion angles would correspond with longer contact time, thus a less efficient stretch-shortening cycle and most of the energy would dissipate as heat (7). Therefore, decreasing the GCT during a DJ is desirable in plyometric training. Despite no significant differences in any of the kinetic and kinematic (Table 1 & 2) variables in the DJ, the EXT RSI tended to be superior compared to the other conditions. According to the CAH it can be suggested that a higher movement efficiency led to such results. An increased muscle fibre recruitment could have been a possible explanation for a higher movement efficacy. An EXT has shown to facilitate movement coordination and performance by optimising muscle fibre recruitment as measured with electromyography (EMG) (39, 56, 74). Although, it has been shown, that different instructions affect the execution of the DJ (7, 16, 30) further research is needed to fully understand the effect of different foci of attention on muscle fibre recruitment pattern during a DJ.

No significant differences could be observed in any of the joint moment (Table 1) between the conditions in the DJ. The current joint moments in the DJ (Table 1) were found to be inconsistent with previous research (6, 7). DJ from a 20 cm height produced peak moments at the ankle, knee and hip of 310 Nm, 558 Nm and 602 Nm respectively (6) and from a 40 cm height ~400 Nm, ~600 Nm and ~400 Nm, respectively (7). Others found relative peak moments at the ankle and knee between 5-7 Nm/Kg and -7-9 Nm/Kg, respectively (61). However, peak and relative peak hip joint moments tended to be higher in both experimental groups compared to the CON, which also displayed a higher peak flexion angle in the hip. It could be suggested, that a higher range of movement in the EXT and INT increased the corresponding hip moments. However, increasing jump height has been shown to be in relation with increasing hip joint moments (34). This is contrary to the current findings, as the EXT jump height was superior to the INT. However, hip joint moments in the current study seemed too high. Individual hip moment of above 4000 Nm are unrealistic. The current values in the hip joint moments during the DJ indicate a methodical flaw during data recoding process. Further discussion of the joint moments in the DJ would be speculative due to the unrealistic values.

However, it can be speculated that the lack of significant kinematic and kinetic changes is because of the complexity of the DJ. Others have suggested, that the DJ is too complex to benefit from an EXT (37). They argued, that from a motor control point of view, it is necessary to adjust many degrees of freedom in a very short time in order to optimise performance. Therefore, it can be theorised, that the complexity of the movement may have overloaded the potential benefits of an EXT. As previously demonstrated, an EXT might not always increase performance outcome in well-trained athletes. Further, it has been shown, that neither an INT nor an EXT facilitated performance of a complex task in trained athletes (3, 44). All subjects in the current study can be classified as well-trained athletes, who regularly incorporate the DJ in their training routine. Therefore, it can be suggested that the EXT had only little effect on the kinetics and kinematic of the DJ between the conditions, because the subjects already used optimal movement coordination strategies. Therefore, task complexity tends to be a relevant variable, when choosing the optimal instruction for athletes of different levels. Further it is possible, that the optimal instruction in terms of attentional focus is not yet established and therefore additional research is needed to find the optimal cue in DJ.

The different instructions lead to intra-individual performance differences (Table 4). The EXT elicited significantly more best performances compared to the other conditions. No significant difference was found in the DJ between the conditions. However, the INT tended to demonstrate an inferior response independent of the task. Therefore, it is imperative for the practitioner to know under which instruction each athlete is eliciting the best performance.

Consistent with previous findings, the results of the current study demonstrate that even well-trained athletes profit from an EXT. The EXT induced a superior jump performance compared to the other conditions. This was attributed to a changed movement coordination, as measured by F_{min} and t_{Fmin}, and probably to a more efficient movement pattern. Similarly, in the DJ an EXT increased jump performance and tended to facilitate the RSI compared to the INT and CON. However, no significant changes in the kinetic and kinematic data allowed a conclusive argument for the change in performance in the DJ. As relevant research is inconclusive in quantifying the effect of different instructions on DJ performance, it can be suggested, that an improved movement efficiency was, at least to some point, responsible for the increased jump performance.

A potential limitation in this study is the use of handball player, as the results may not be transferable to other populations. As each subject was usually tested before his mandatory strength session, other team members were generally also in the testing location, which could have distracted the subjects and influence their performance. Further, the force plates only measured vertical forces. For the subsequent IDA horizontal forces were neglected. More valid results could be expected with additional horizontal forces, as this would increase the validity of the joint moments. However, this would have increased the overall joint moments in this study, which would have made some results even more unrealistic in the DJ. Also the high speed camera was only recording at a resolution of 720x1280, which made it difficult to track the exact position of the marker, while digitizing the coordinates.

PRACTICAL APPLICATION

From a practical standpoint, the current results show an immediate improvement in jump performance when an EXT was used in well trained handball athletes. A concomitant change movement coordination with an increase in hip moments and reduced knee moments tended to be the underlying biomechanical change. INT and CON are less effective in order to elicit best performance and should therefore be avoided. The subjects' regular jumping strategy (i.e. CON condition) indicated not to be optimal to maximise performance. Based on the current results it seems to be essential for the practitioner to be proficient in a range of EXT depending on the task and the population in order to promote effective training and maximise performance.

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APPENDIX

Ethics application

St Mary's University
Twickenham
London

St Mary's University

Ethics Sub-Committee

Application for Ethical Approval (Research)

This form must be completed by any undergraduate or postgraduate student, or member of staff at St Mary's University, who is undertaking research involving contact with, or observation of, human participants.

Undergraduate and postgraduate students should have the form signed by their supervisor, and forwarded to the School Ethics Sub-Committee representative. Staff applications should be forwarded directly to the School Ethics Sub-Committee representative. All supporting documents should be merged into one PDF (in order of the checklist) and clearly entitled with your **Full Name, School, Supervisor.**

Please note that for all undergraduate research projects the supervisor is considered to be the Principal Investigator for the study.

If the proposal has been submitted for approval to an external, properly constituted ethics committee (e.g. NHS Ethics), then please submit a copy of the application and approval letter to the Secretary of the Ethics Sub-Committee. Please note that you will also be required to complete the St Mary's Application for Ethical Approval.

Before completing this form:

- Please refer to the **University's Ethical Guidelines**. As the researcher/ supervisor, you are responsible for exercising appropriate professional judgment in this review.
- Please refer to the Ethical Application System (Three Tiers) information sheet.
- Please refer to the Frequently Asked Questions and Commonly Made Mistakes sheet.
- If you are conducting research with children or young people, please ensure that you read the **Guidelines for Conducting Research with Children or Young People**, and answer the below questions with reference to the guidelines.

Please note:

In line with University Academic Regulations the signed completed Ethics Form must be included as an appendix to the final research project.

If you have any queries when completing this document, please consult your supervisor (for students) or School Ethics Sub-Committee representative (for staff) .

St Mary's Ethics Application Checklist

The checklist below will help you to ensure that all the supporting documents are submitted with your ethics application form. The supporting documents are necessary for the Ethics Sub-Committee to be able to review and approve your application.

Please note, if the appropriate documents are not submitted with the application form then the application will be returned directly to the applicant and may need to be re-submitted at a later date.

	Enclosed? (delete as appropriate)		Version No
Document	Yes	Not applicable	
1.Application Form	Mandatory		
2.Risk Assessment Form	✓		
3.Participant Invitation Letter	✓		
4.Participant Information Sheet	Mandatory		
5.Participant Consent Form	Mandatory		
6.Parental Consent Form		✓	
7.Participant Recruitment Material - e.g. copies of Posters, newspaper adverts, website, emails		✓	
8.Letter from host organisation (granting permission to conduct the study on the premises)		✓	
9. Research instrument, e.g. validated questionnaire, survey, interview schedule		✓	
10.DBS included		✓	
11.Other Research Ethics Committee application (e.g. NHS REC form)		✓	

I can confirm that all relevant documents are included in order of the list and in one PDF document entitled with you: ***Full Name, School, Supervisor.***

Signature of Applicant: Daniel Kadlec D. K

Signature of Supervisor:

Ethics Application Form

1) Name of proposer(s)	Daniel Kadlec
2) St Mary's email address	135084@live.stmarys.ac.uk
3) Name of supervisor	Dr Daniel Cleather

4) Title of project: Effects of different attentional foci on kinematic and kinetic variables in countermovement jumps and drop jumps in trained athletes

5) School or service	School of Sport, Health & Applied Science
6) Programme (if undergraduate, postgraduate taught or postgraduate research)	MSc. Strength and Conditioning; postgraduate research
7) Type of activity/research (staff / undergraduate student research / postgraduate student)	Postgraduate Student

8) Confidentiality	
Will all information remain confidential in line with	YES

the Data Protection Act 1998	

9) Consent	
Will written informed consent be obtained from all participants / participants' representatives?	YES

10) Pre-approved protocol	
Has the protocol been approved by the Ethics Sub-Committee under a generic application?	NO Date of approval:

11) Approval from another Ethics Committee	
a) Will the research require approval by an ethics committee external to St Mary's University?	NO
b) Are you working with persons under 18 years of age or vulnerable adults?	NO

12) Identifiable risks	
a) Is there significant potential for physical or psychological discomfort, harm, stress or burden to participants?	NO
b) Are participants over 65 years of age?	NO
c) Do participants have limited ability to give voluntary consent? This could include cognitively impaired persons, prisoners, persons with a chronic physical or mental	NO

condition, or those who live in or are connected to an institutional environment.	
d) Are any invasive techniques involved? And/or the collection of body fluids or tissue?	NO
e) Is an extensive degree of exercise or physical exertion involved?	YES - maximal effort jumping
f) Is there manipulation of cognitive or affective human responses which could cause stress or anxiety?	NO
g) Are drugs or other substances (including liquid and food additives) to be administered?	NO
h) Will deception of participants be used in a way which might cause distress, or might reasonably affect their willingness to participate in the research? For example, misleading participants on the purpose of the research, by giving them false information.	NO
i) Will highly personal, intimate or other private and confidential information be sought? For example sexual preferences.	NO
j) Will payment be made to participants? This can include costs for expenses or time.	NO
k) Could the relationship between the researcher/ supervisor and the participant be such that a participant might feel pressurised to take part?	NO

13) Proposed start and completion date

Please indicate: • When the study is due to commence. • Timetable for data collection. • The expected date of completion. Please ensure that your start date is at least 3 weeks after the submission deadline for the Ethics Sub-Committee meeting.
Start of data collection: December; End of data collection January

14)Sponsors/Collaborators
Please give names and details of sponsors or collaborators on the project. This does not include you supervisor(s) or St Mary's University. • Sponsor: An individual or organisation who provides financial resources or some other support for a project. • Collaborator: An individual or organisation who works on the project as a recognised contributor by providing advice, data or another form of support.
No sponsors or collaborators are available

15. Other Research Ethics Committee Approval
• Please indicate whether additional approval is required or has already been obtained (e.g. the NHS Research Ethics Committee). • Please also note which code of practice / professional body you have consulted for your project • Whether approval has previously been given for any element of this research by the University Ethics Sub-Committee.
No other additional approval is required

16. Purpose of the study

In lay language, please provide a brief introduction to the background and rationale for your study.

- Be clear about the concepts / factors / performances you will measure / assess/ observe and (if applicable), the context within which this will be done.
- Please state if there are likely to be any direct benefits, e.g. to participants, other groups or organisations.

The purpose of the study is to determine which coaching cue, with regards to attentional focus and the constrained action hypothesis, elicits the highest jump performance in counter-movement jumps and drop jumps. Instructions with an external compared to an internal focus of attention has shown to elicit superior performance outcomes in a variety of tasks.

Jumping is crucial ability in a variety of sports. In many sporting situations success is dependent on an athlete's ability to jump higher than his opponent in the given amount of time. For example during a handball jump throw, a basketball rebound, a volleyball block or a track and field height jump. Jumping exercises rely on the stretch shortening cycle. The stretch shortening cycle is defined as rapid eccentric lengthening under tension followed by a quick isometric amortization phase resulting in a explosive concentric contraction. It has been reported, that depending on the characteristics of the jumping exercise the stretch shortening cycle can be classified either as a short and a long stretch shortening cycle. The short stretch shortening cycle is characterised with short ground contact times (under 0.2s), a small displacement of the athlete's centre of gravity and a relative small change in joint angles during the motion as seen in a drop jump (DJ). The long stretch shortening cycle is suggested to have longer ground contact times (over 0.2s), a relative high displacement if the athlete's centre of gravity and a greater changes in joint angles as seen in the countermovement jump (CMJ). Furthermore, the stretch shortening cycle is an essential part of other sports related skills like accelerating, sprinting and changing direction. Plyometric exercises are beneficial in order to improve the stretch shortening cycle and thus increasing the athletic potential of an athlete. Depending of the sports and athlete an integral part of the training might be to increase the performance outcomes in a counter movement jump and/or a drop jump.

Different studies already demonstrated, that an external attentional focus leads to significant better jumping performance (jump height for CMJ; jump height and ground contact time in DJ). However, there is a paucity of research, how different foci affect the kinetics and kinematics throughout the motion of a CMJ and a DJ. Several studies reported increased jump performances with an EXT compared to an INT, while producing similar amounts of GRF. However, they were unable to explain those performance differences. Knowing how the kinematics are altered in response to a specific instruction will demonstrate why an EXT produces superior jumping performances.

Furthermore, it hasn't been shown which specific instruction leads to an enhanced reactive ability as measured in the drop jump. Depending on the instruction provided, either both contact time and flight time increased or decreased. The aim in drop jumps is to minimize contact time and increasing jump height simultaneously in order to get the desired adaptation. A higher mechanical output during a CMJ or DJ is associated with a more effective stimulus applied, which lead the desired adaptation. A simple change in words can already alter the given movement. Therefore, knowing what specific instruction are best suited to elicit the desired outcomes over the short term is essential for the practitioner.

Evaluating the underlying biomechanical causes that affect performance will offer further insights in the research area of attentional focus and human movement. Getting a more in depth understanding about how to instruct athletes to produce maximal performance is essential to deliver the best content possible within each session for the practitioner and the scientific community.

17. Study Design/Methodology

In lay language, please provide details of:

a) The design of the study (qualitative/quantitative questionnaires etc.)
b) The proposed methods of data collection (what you will do, how you will do this and the nature of tests).
c) You should also include details regarding the requirement of the participant i.e. the extent of their commitment and the length of time they will be required to attend testing.
d) Please include details of where the testing will take place.
e) Please state whether the materials/procedures you are using are original, or the intellectual property of a third party. If the materials/procedures are original, please describe any pre-testing you have done or will do to ensure that they are effective.

The study design is a quantitative experiment. A force plate (PASCO) and a high speed camera will obtain kinematic and kinetic data from different jumps of the participants. Furthermore, it is planed to measure joint angles and during the motion with a high speed camera and calculate muscle/joint moment via inverse dynamics. In order to calibrate the high speed camera, two poles of known height (60 cm) are placed 50 cm apart in the centre of the field of view. A trigger switch is used to synchronise kinetic and kinematic data through a synchronisation unit.

The testing procedure will take roughly 35-40 minutes per subject. All participants are required to conduct maximal effort jumping tasks. Before the time of testing, all subjects are informed about their tasks they need to conduct. After entering the testing environment, a private gym, each subject needs to a agree and sign the consent form. Further, they need to confirm, that they are free of any musculoskeletal injury for at least 6 weeks.

After a standardized warm up protocol each participant is instructed with all necessary information about the upcoming procedure. The warm up protocol consists of a general 5 minute warm up on a stationary bike at 60-80 watts with a cadence of 70-80 rpm, followed by 10 bodyweight squats, 10 alternating reverse lunges (5 each leg). After a 1 minute rest the participants performs 5 submaximal non-consecutive countermovement jumps and 5 submaximal drop jumps from approximately 40 cm. The participant takes a rest, when the markers for the motion capture are attached to the left side (toe, ankle, knee, hip and shoulder). Before executing the first series of maximal jump while kinetic

and kinematic data are measured the participant is told what to focus on during the different jumps. The participants then starts with three non-continuous counter-movement jumps with at least 15 seconds rest between the jumps to determine the baseline value with the instruction "jump to the best of your abilities while maintaining hands on hips". All jump are executed with hands on hips to make the result more comparable to other scientific studies. After a 3 minute seated rest the participant performs 3 drop jumps from approximately 40 cm with at least 15 seconds rest between the jumps with the instruction "jump to the best of your abilities while maintaining hands on hips". The participant rests again for 3 minutes and is then randomly assigned to one of two experimental group, where he will repeat the same jumps but with another instruction. Every subject will receive the respective instruction before the execution of each single jump to increase the likelihood to retain the specific instruction. One experimental (External cue) conditions was "touch the hanging ball over your head while maintaining hands on hips" for the counter movement jump and "Push the ground as fast and forcefully away as possible and reach for hanging ball over your head while maintaining hands on hips " for the drop jump. The other experimental condition (Internal cue) was for both jumps "extend your hip and knee as forcefully and fast as possible while maintaining hands on hips".
All CMJ are performed on the force plate. During the DJ, the force plate is placed beside the box. All subjects are required to wear spandex shorts. Drop jumps and countermovement jump are counterbalanced across subjects to eliminate order effects. The subjects don't receive any kind of feedback about their performance during the testing.
With the kinematic and kinetic data obtained from each participant, the author can then analysis how each jump was performed, what forces/ joint moments occurred and how they differed between the subjects and different conditions. The jumping tasks will be held in a private gym (Plus D Sports, Vohwinkeler Str. 119a, 42329 Wuppertal, Germany), where the participants usually conduct their strength training.

18. Participants

Please mention:

a) The number of participants you are recruiting and why. For example, because of their specific age or sex.
b) How they will be recruited and chosen.
c) The inclusion / exclusion criteria's.
d) For internet studies please clarify how you will verify the age of the participants.
e) If the research is taking place in a school or organisation then please include their written agreement for the research to be undertaken.

Around 40 male well-trained athletes from 4 different handball teams are recruited for this study to determine the effects on a highly trained population. All participants are already training on a weekly basis under the authors guidance and therefore already familiar with the environment and the different jumps. All possible subjects will be informed about the study during the inseason and asked if they want to participate. Testing is planed to be during the Christmas brake. Only healthy subjects without any injuries will participate in this study. The age range is between 18 and 38.

19. Consent
If you have any exclusion criteria, please ensure that your Consent Form and Participant Information Sheet clearly makes participants aware that their data may or may not be used. a) Are there any incentives/pressures which may make it difficult for participants to refuse to take part? If so, explain and clarify why this needs to be done b) Will any of the participants be from any of the following groups? ➢ Children under 18 ➢ Participants with learning disabilities ➢ Participants suffering from dementia ➢ Other vulnerable groups. c) If any of the above apply, does the researcher/investigator hold a current DBS certificate? A copy of the DBS must be included with the application. d) How will consent be obtained? This includes consent from all necessary persons i.e. participants and parents.
Participation is on a voluntary basis for each subject. Only healthy adult subjects without any form of physical or psychic deficiencies will participate. Each subject willing to participate will have to read through the consent form and sign it, if everything is clear to the subject.

20. Risks and benefits of research/ activity
a) Are there any potential risks or adverse effects (e.g. injury, pain, discomfort, distress, changes to lifestyle) associated with this study? If so please provide details, including information on how these will be minimised. b) Please explain where the risks / effects may arise from (and why), so that it is clear why the risks / effects will be difficult to completely eliminate or minimise. c) Does the study involve any invasive procedures? If so, please confirm that the researchers or collaborators have appropriate training and are competent to deliver these procedures. Please note that invasive procedures also include the use of deceptive procedures in order to obtain information.

d) Will individual/group interviews/questionnaires include anything that may be sensitive or upsetting? If so, please clarify why this information is necessary (and if applicable, any prior use of the questionnaire/interview).

e) Please describe how you would deal with any adverse reactions participants might experience. Discuss any adverse reaction that might occur and the actions that will be taken in response by you, your supervisor or some third party (explain why a third party is being used for this purpose).

f) Are there any benefits to the participant or for the organisation taking part in the research (e.g. gain knowledge of their fitness)?

The possibility of a musculoskeletal injury is given during the jumping tasks, but a evidence based warm up protocol will minimize the risk prior to the testing. Maximal effort jumping may impose the subject to a injury to their body. However, each subjects is already familiar with this exercise as it is part of their sport.

If a participant suffers an injury during the warm up or the jumping tasks, the test will be cancelled and postponed to another date, when the subjects is healthy. The author is first aid trained. A cooperating physiotherapy office is next to the gym, where musculoskeletal injuries could be immediately treated. Further, the co-worker of the gym is a qualified intensive care nurse and a defibrillator is available in the same building.

Each participant will get information about their current level of fitness, in particular their jumping abilities. A written statement including all relevant data from the two different jumping tasks will be handed over via email to the subject after all data is collected. For the DJ the relevant data are jump height, ground contact time and the reactive strength index. The relevant CMJ data is jump height. Additional the mean value with a standard deviation will be presented of all data.

21. Confidentiality, privacy and data protection

a) What steps will be taken to ensure participant's confidentiality?

- Describe how data, particularly personal information, will be stored.
- Consider how you will identify participants who request their data be withdrawn, such that you can still maintain the confidentiality of theirs and others data.

b) *Describe how you manage data using a data a management plan.*

- *You should show how you plan to store the data securely and select the data that will be made publically available once the project has ended.*
- *You should also show how you will take account of the relevant legislation including that relating data protection, freedom of information and intellectual property.*

c) Who will have access to the data? Please identify all persons who will have access to the data (normally yourself and your supervisor).

d) Will the data results include information which may identify people or places?

- Explain what information will be identifiable.
- Whether the persons or places (e.g. organisations) are aware of this.
- Consent forms should state what information will be identifiable and any likely outputs which will use the information e.g. dissertations, theses and any future publications/presentations.

Each participant will get a subject-number. The information sheet and consent form of each participant will be organized and stored in a private and lockable office and held on a password protected computer, where only the author have access. If a participant wants to withdrawal, his data will be completely erased.

The mean values of all participants anthropometric measures, age and the kinetic and kinematic variables will be published in the thesis and possibly in a future publication.
Only me and my supervisor will have access to the data. The data will be stored on the private computer which is protected with a code.
The data will contain anthropometric measures, age and the kinetic and kinematic variables from the jumping task. All information gathered and its purpose for the thesis will be explained in the information sheet. The participation will be kept confidential without involvement of third parties.

22. Feedback to participants

Please give details of how feedback will be given to participants:

- As a minimum, it would normally be expected for feedback to be offered to participants in an acceptable to format, e.g. a summary of findings appropriate written.
- Please state whether you intend to provide feedback to any other individual(s) or organisation(s) and what form this would take.

Each participant will get, if requested, a written statement of his results kinetic and kinematic results in the jumping task. No other individuals nor organisation will get any form feedback.

The proposer recognises their responsibility in carrying out the project in accordance with the University's Ethical Guidelines and will ensure that any person(s) assisting in the research/ teaching are also bound by these. The Ethics Sub-Committee must be notified of, and approve, any deviation from the information provided on this form.

Signature of Proposer(s)	Date: 11.01.16
Signature of Supervisor (for student research projects)	Date:

Approval Sheet

Name of applicant:	Daniel Kadlec
Name of supervisor:	Dr Daniel Cleather
Programme of study:	MSc. Strength and Conditioning
Title of project:	Effects of different attentional foci on kinematic and kinetic variables in countermovement jumps and drop jumps in trained athletes

Supervisors, please complete section 1 or 2. If approved at level 1, please forward a copy of this Approval Sheet to the School Ethics Representative for their records.

SECTION 1
Approved at Level 1
Signature of supervisor (for student applications)..
Date..

SECTION 2 Refer to School Ethics Representative for consideration at Level 2 or Level 3 Signature of supervisor... Date...
SECTION 3 To be completed by School Ethics Representative Approved at Level 2 Signature of School Ethics Representative.. Date...
SECTION 4 To be completed by School Ethics Representative. Level 3 consideration required byt the Ethics Sub-Committee (including all staff research involving human participants) Signature of School Ethics Representative.. Date... Level 3 approval – confirmation will be via correspondence from the Ethics Sub-Committee

Information sheet

Information Sheet

Why you: You are a male adult elite or sub-elite athlete with sufficient experience in resistance training and jumping activities.

Participation: The participation is voluntary and you can withdraw any time of the study without giving any reason.

Procedure: After a standardized warm up, you have to complete 4 series of different jumping tasks with 3 repetitions, respectively. Before each set and every repetition you will receive a special coaching cue that you need to focus on. The testing procedure will take about 35 minutes in total.

Risks: Conducting research imposes the possibility of harmful events. Therefore, you are informed about your rights in the case of any unforeseen events. The possibility of a musculoskeletal injury is given during the jumping tasks. Proper warm up will minimize the risk. Furthermore, you should only participate, if you are free of any injury. Every care will be taken to minimize the likelihood of any harm that can occur during the participation in the study. In the unlikely event of any injury, insurance arrangements are provided by St Mary's University.

Preparation: Please keep to your usual nutritional and sleeping habits 24 hours before the procedure. You should be sufficient rested to execute several maximal effort jumps, therefore you should avoid any strenuous activities 24 hours before the testing.

Data: All relevant data from you will be used for the author's MSc. thesis and a potential scientific publication. Therefore, your data may be made publicly available, but it will not be possible to identify you. The information sheet and consent form of you will be organized and stored in a private office and or a lockable computer. Your participation will be kept confidential without involvement of third parties.

Benefits: You will receive your result of the jumping tasks with all relevant data, which will be explained to you and provide you useful information for your own training.

YOU WILL BE GIVEN A COPY OF THIS FORM TO KEEP TOGETHER WITH A COPY OF YOUR CONSENT FORM

Consent form

Name of Participant: ______________________________

Title of the project: Effects of different attentional foci on kinematic and kinetic variables in countermovement jumps and drop jumps in trained athletes

Main investigator and contact details: Daniel Kadlec
Email: 135084@live.stmarys.ac.uk
Phone: 0049 176 31168146

Members of the research team: Dr. Daniel Cleather - daniel.cleather@stmarys.ac.uk

1. I agree to take part in the above research. I have read the participant information sheet which is attached to this form. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.
2. I understand that I am free to withdraw from the research at any time, for any reason and without prejudice.
3. I have been informed that the confidentiality of the information I provide will be safeguarded.
4. I am free to ask any questions at any time before and during the study.
5. I have been provided with a copy of this form and the Participant Information Sheet.

Data Protection: I agree to the University processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Name of participant (print)……………………….Signed………………..….Date………………

Name of witness (print)……………………………..Signed………………..….Date………………

If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project: ____

I WISH TO WITHDRAW FROM THIS STUDY

Name: ______________________________

Signed: _________________________ Date: _______________