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DO LOWER-LIMB KINEMATIC AND KINETIC ASYMMETRIES TRANSFER ACROSS SPRINT RUNNING AND COUNTERMOVEMENT JUMPS IN UNIVERSITY RUGBY UNION PLAYERS?

Authors: Lewis J. Vizard[1], Gareth Peden[1] and Maximilian M. Wdowski[1]

[1]Faculty of Health and Life Sciences, Coventry University, Coventry, UK;

Corresponding Author: Maximilian M. Wdowski

Address:

Level 2, Science and Health Building

Faculty and Health and Life Sciences,

Coventry University,

CV1 5FB,

United Kingdom

Email: ac60721@coventry.ac.uk

Biographical notes;

Lewis J. Vizard (BSc) – Is a graduate in Sports Therapy, from the School of Life Sciences Coventry University, UK

Gareth Peden (BSc) – Is a graduate in Sports Therapy from the School of Life Sciences, Coventry University, UK.

Maximilian M. Wdowski (PhD) – Is Lecturer in Sport and Exercise Biomechanics in the School of Life Sciences, Coventry University, UK.

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Key Points

- Lower-limb kinematic and kinetic asymmetries may transfer between dynamic movements
- Individual level asymmetries present in lower-limb kinematics and kinetics during sprint running and countermovement jumps

Key Words

Injury, Performance, Screening

Abstract

The aim was to examine if lower-limb kinetic and kinematic asymmetries are transferred between sprint running and countermovement jumps in a group of university Rugby Union players. Eight university Rugby Union players (20.3±1.6 years) participated in the study. Three-dimensional kinematic and force platform data recorded sprint runs and countermovement jumps. Across the two movements there was a substantial and moderate level of agreement for the ankle ROM and peak normalised GRF, respectively. No significant difference between inter-limb kinematic and kinetic variables at the group level. Lower-limb asymmetries may be transferred across dynamic movements and are present at the individual level.

Introduction

Rugby Union is an intermittent contact sport that exposes players to short-duration, high-intensity activities that include, but are not limited to, high-speed running, sprinting, collisions and tackling.[1-2] The largest playing pathway for young Rugby Union players in England is within the school or education programme.[3] Following school, adolescents may continue their education at a university, whereby further participation in Rugby Union can also take place.[4] However, injury incident rates during match-play in young Rugby Union players participating within a regional (professional) academy is 47 per 1000 player-hours.[5] Therefore, it is important to further understand the demands and potential for injury of the dynamic movements required at the university stage of the Rugby Union pathway.

Inter-limb asymmetry compares the movement of one limb with respect to the other.[6] The assessment of movement control and inter-limb asymmetry during functional tasks is becoming increasingly popular as a means of screening for predisposition to injury.[7] Inter-limb differences measured across a range of tasks could have a detrimental effect on physical and sport performance,[8] and include potentially injurious concerns.[9] Asymmetry has been implicated in a number of joints as an injury risk factor for the development of lower extremity injury. For example, angle and moment variables at the ankle,[10-11] knee,[12-13] hip,[14-15] as well as ground reaction forces (GRF) [16] have been suggested as injury risk factors.

U18 Rugby Union players playing as a back complete a total sprint running distance of 319±176 m during a match, with forwards completing 64±65 m of sprinting and 1112±442 m of striding, making it a key dynamic movement in the sport.[4] Despite a large number of studies that have focused on kinematic or kinetic asymmetry in submaximal running and walking gait,[17-20] asymmetry has rarely been investigated in sprint running. Therefore it is important to further understand the potential lower-limb asymmetries that may be present in university level Rugby Union players during a sprint run.

The countermovement jump (CMJ) has proven a reliable test for measuring force and power output[21] and it is commonly used by elite level Rugby Union team's strength and conditioning coaches,[22] as the mechanics of the jump can be implemented to a number of sport specific movements.[23] Furthermore, the CMJ has been used as a screening tool to measure lower-limb asymmetry.[24] However, there has been limited research conducted to suggest that lower-limb kinematic and kinetic asymmetries that are present in a CMJ are transferred to other dynamic movements required of the sport.

Therefore, the aim of the study was to examine whether lower-limb kinematic and kinetic asymmetries would be present across sprint running and CMJ's in a cohort of university level Rugby Union players. It was hypothesised that there would be asymmetries present in both the countermovement jumps and the sprint runs but that there would be limited transfer of specific lower-limb asymmetries.

Methods

Participants

8 male Rugby Union players from the University 1st and 2nd team (mean ± SD: age 20.3±1.6 years; mass 88±9.6kg; height 183±0.6cm) participated in the study. The players selected were all were injury free at the time of testing. All participants provided informed consent, and the study procedures were approved by an institutional research ethics committee.

Instrumentation

Prior to testing the ankle and knee width were measured, for both lower-limbs, using an Anthropometer (Lafayette). A tape measure (Seca 201) was used to measure both leg lengths from the anterior-superior iliac spine to the lateral malleolus. A twelve camera 3D motion analysis system (Vicon – Vantage 5, UK), synchronized with four 40x60cm force platforms (Kistler – 9281E, Switzerland), was used to collect movement data. Vicon Nexus 2.7 software controlled simultaneous collection of motion and force data at 120Hz and 960Hz, respectively and both were filtered using a fourth order Butterworth filter with a cut-off frequency of 10Hz.

Tasks

The participants were taken through a warm up focusing on dynamic movements for sprinting and the CMJ. Sixteen reflective markers were then placed using double-sided tape on specific bony landmarks of the lower limb.[25] The CMJ was completed first with the participant asked to perform three trials of a maximal CMJ jump from a standing position, with one foot on each force platform, with their hands positioned on their hips. Three maximal sprint running trials were then collected for both a left foot strike and a right foot strike. For the right foot strike, the participants started with their left foot forward and made contact with the force platform for the first stance phase of the right foot. This was reversed for the left foot strike sprints. The participants were instructed to sprint maximally for 10 m from the standing start position.

Procedures

The trials where the foot strike connected with the centre of the force platform were used for further analysis. The Vicon Lower Body PlugInGait modelling pipeline defined rigid body segments (foot, shank, thigh and pelvis) and used standard inverse dynamics techniques to calculate joint kinematics and kinetics. Peak ground reaction forces normalised to body weight, Ankle, knee, and hip angles were calculated as well as internal joint moments and power at the hip, knee and ankle during foot contact with the force plate. Angles were normalised to a standing static trial and, as a consequence of sprint running and CMJ movements predominantly occurring in the sagittal plane, no transverse or frontal plane kinematic or kinetics were reported. Peak maximum and minimum values for variables were obtained for the stance phase of the sprint run and from the onset of the eccentric drop phase of the CMJ until take-off.

Statistical Analysis

There are many methods of calculating the magnitude of asymmetry between right and left lower-limbs but the symmetry angle, first suggested by Zifchock et al.,[26] has been suggested as the most appropriate method.[27] Bishop et al.'s[27] method for calculating the symmetry angle in excel was implemented (See Equation 1), with the slight change to divide the smaller of the left or right value by the larger, therefore enabling group based means and standard deviations to be employed. Symmetry angles were calculated for all kinematic and kinetic measures between the right and left leg in both the sprint run and CMJ. Essentially, 2 identical values would create a 45° angle in relation to the x axis and therefore perfect symmetry. The results are then be multiplied by 100 converting it to a percentage, a score of 0% indicating perfect symmetry, which is then comparable with all other measurements of asymmetry.[27]

Equation 1.

$$Step\ 1 \coloneqq DEGREES\left(ATAN\left(\frac{SMALL\ VALUE}{LARGE\ VALUE}\right)\right) = x$$

$$Step\ 2\colon \left(\frac{45 - x}{90}\right) * 100 = Symmetry\ Angle$$

For all variables a Levene's test and a Kolmogorov-Smirnov test was used to examine equality of variance and normality of distribution, respectively. To assess asymmetry at the group level Independent T-tests were performed on all kinematic and kinetic variables between right and left legs. Cohen's Kappa was used to examine the transfer of asymmetries between the CMJ and sprint run, as it has previously been advocated to assess asymmetry transfer.[28] A participant was rated as having a 1 for a variable if the left variable was greater and a 0 if the right variable was greater. Cohen's Kappa can range from −1 to +1, where 0 represents the amount of agreement that can be expected from random chance, and 1 represents perfect agreement between the raters.[29]

Results

The symmetry angle was greatest in the knee moment (11.9±11.1) and knee joint ROM (10.9±10.7) and knee joint power (16.9±11.6) during sprint running, and hip power (11.8±10.3) and knee joint power (16.9±11.6) in the CMJ (See Table 1). Kinematic and kinetic variables were found to be similar between right and left legs at the group level ($P>0.05$). Between sprint running and CMJ there was a substantial and moderate level of agreement for the ankle range of motion ($\kappa = 0.714$; $P = 0.035$) and peak normalised GRF ($\kappa = 0.500$; $P = 0.157$), respectively (See Table 2). Individual level symmetry angles (Table 3.) ranged from 0.1-35.1 %.

INSERT TABLE 1, 2 & 3 HERE

Discussion

The study aimed to examine whether lower-limb kinematic and kinetic asymmetries would be present across sprint running and CMJ's in a cohort of university level Rugby Union players. It was hypothesised that there would be asymmetries present in both the countermovement jumps and the sprint runs but that there would be limited transfer of specific lower-limb asymmetries.

In reference to the first hypothesis, at the group level there were no significant differences between right and left leg during either sprint running or CMJ, however medium effects were observed for several variables. Medium effects were observed during the CMJ for ankle, knee and hip joint power, suggesting the need for future research to examine the potential asymmetry in muscle power production during a CMJ between the left and right limbs. While there were no significant asymmetries at the group level, at the individual level several variables exhibited large symmetry angles (SA). For example the symmetry angle ranges at the individual level were 1.0-31.8 % and 0.3-33.4 % for the hip power during the CMJ and hip power in sprint running, respectively. Furthermore, not one participant was under the suggested 10–15% inter-limb asymmetry threshold,[30] that is thought problematic and requiring an intervention, for every kinematic and kinetic variable measured. The absence of any meaningful inter-limb differences at the group level could be a consequence of individualised movement patterns and developed asymmetries. For example, during CMJ's participant 1 had greater SA at the ankle ROM (7.8 %) compared to the hip ROM (3.2 %), whereas participant 2 had lower SA at the ankle ROM (0.3 %) than at the hip ROM (5.4 %). Bishop et al.[28] argued that with asymmetries rarely being present on the same side across tests, these results show that a more individual approach to reporting asymmetries is required, which should help practitioners when designing targeted training interventions for the reduction of asymmetries. Therefore, the results of the current study suggest that asymmetries may be more the norm than the exception. Given the potential injury risk of lower-limb asymmetries, practitioners should screen for asymmetrical movements and potentially implement conditioning measures in an effort to reduce the level of asymmetry present.

Regarding the second hypothesis, the findings of the current study suggest that lower-limb asymmetry may be transferred across dynamic movements for specific kinematic and kinetic variables. There was a substantial and moderate level of agreement for the ankle range of motion ($\kappa = 0.714$; $P = 0.035$) and peak normalised GRF ($\kappa = 0.500$; $P = 0.157$), respectively. These are the first indications that an individual's lower-limb asymmetries may be transferred across dynamic movements in university Rugby Union players. The ankle joint movement is considered the key contributor to centre of mass acceleration during sprint running,[31] and although the current study measured total ankle ROM and not dorsiflexion/plantarflexion elements separately, high ankle dorsiflexion ROM has been shown to contribute to CMJ jump performance in men.[32] The ankle joint is the last joint in a proximal–distal pattern of peak joint powers in the kinetic chain so perhaps there is a propagation of asymmetrical movements that result in the ankle joint being a more consistent location for lower-limb asymmetries across dynamic movements. The moderate level of agreement between dynamic movements for the peak normalised GRF ($\kappa = 0.500$; $P = 0.157$) potentially provides practitioners with a screening variable that is quickly and easily calculated to be used across a number of different dynamic movements. If force platforms are not readily available, other effective methods of estimating GRF can be used to implement a screening protocol.[34]

The main limitations of the current study are that the relatively small sample size ($N = 8$), which may have not been large enough to fully realise the fair to moderate strengths of association and medium effect sizes with statistical significance, paired with the specificity of the selected cohort somewhat limit the generalisability of the findings. Furthermore, Rugby Union is not a one dimensional sport that is restricted to straight line running and standing CMJ's - it is multi-dimensional. Although sprint running is a key performance skill and CMJ's are used widely in strength and conditioning practices in Rugby Union, future research should examine multiplane dynamical movements, in addition to sprint running and CMJ, to see if the ankle ROM and peak normalised GRF transfer as well. Finally, research should focus on the individual level analyses, rather than traditional group based designs, by using single-subject based strategies[33] to further understanding of lower-limb asymmetries.

Conclusion

In conclusion, asymmetries are present at the individual level in lower-limb kinetic and kinematics during counter movement jumps and sprint running. Furthermore, some of these asymmetries may be transferred across the two dynamic movements. Practitioners should potentially consider that lower-limb asymmetries are present in university Rugby Union players across a range of dynamic movements and should assess individuals using a range of relevant and sport specific dynamic movements.

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Tables Captions

Table 1. Group ensemble (n=8) lower-limb joint range of motion (ROM), joint moments, joint powers, normalised ground reaction force (GRF) and symmetry angles in CMJ and sprint running for the right and left legs.

Table 2. Comparative analysis between CMJ and sprint running for lower-limb joint range of motion (ROM), joint moments, joint powers, normalised ground reaction force (GRF) and symmetry angles.

Table 3. Individual symmetry angles (%) for the right and left legs of the lower-limb joint range of motion (ROM), joint moments, joint powers and normalised ground reaction force (GRF) in CMJ and sprint running.