ARE PELVIS AND LOWER EXTREMITY JOINT ANGLES DURING CLINICAL FUNCTIONAL TESTS RELATED TO ANGLES DURING MORE DYNAMIC RUNNING AND DROP JUMP TASKS?

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This study investigated whether peak joint angles during clinical lower extremity functional tests (Small Knee Bend [SKB], Single Leg SKB, Lunge and Hop Lunge) were related to peak angles during more dynamic landing tasks (Running and Drop Jump). Peak three-dimensional angles were quantified for each movement for 25 uninjured adults (22 ±4 years) and 23 uninjured young athletes (11 ±1 years) using a nine camera motion analysis system. In young athletes Pearson correlations between SKB and Drop Jump were moderate to very large (r=0.39 to 0.87). In adults and young athletes correlations between SKB, Single Leg SKB, Lunge and Hop Lunge with Running were moderate to very large (r=0.45 to 0.90). Clinical lower extremity functional screening tests are useful for estimating dynamic lower extremity alignment in adults and young athletes.

KEY WORDS: screening, functional tests, lower extremity, joint angles.

INTRODUCTION: The use of functional screening tests to assess an athlete's movement quality/dynamic alignment is now common (Chiaia, et al., 2009; Reid, Stotter, Schneiders, Hing, & White, 2003). Screening is promoted as a way to decrease an athlete's risk of injury and/or enhance performance. A range of clinical lower extremity functional screening tests have been reported in the literature including the single leg squat, small knee bend, lunge and hop lunge (Cook, 2006; Sahrmann, 2002; Thijs, Van Tiggelen, Willems, De Clercq, & Witvrouw, 2007; Zeller, McCrory, Kibler, & Uhl, 2003). Recently assessment of lower extremity movement quality has been specifically recommended as a screening tool in young athletes (Ford, Myer, & Hewett, 2007; Örtqvist, et al., 2011). The increasing push for physical activity in youth as part of a healthy lifestyle makes the risk of injuries an increasing concern and thus screening for risk factors has increased. In adults and youth, lower extremity movement screening is focused on frontal and transverse plane control of the trunk, pelvis, hip and knee as this has frequently been linked to injury, particularly overuse problems such as patellofemoral dysfunction and iliotibial band syndrome (Powers, 2010; Reiman, Bolgla, & Lorenz, 2009). There are advantages in terms of time, space, equipment and ease of assessment that make the use of simple clinical functional screening tests more feasible than more dynamic movements, or analysis of movements using full biomechanical analysis. These clinical functional tests are assumed to be an effective method of diagnosing movement dysfunction during more dynamic movements such as running and jump landings, however the evidence for this association appears mostly anecdotal. The ability of common clinical lower extremity functional tests to predict movement during the higher velocity, higher impact activities of running and jump landings is largely unknown. Therefore the purpose of this study was to investigate whether pelvis and lower extremity peak joint angles during clinical lower extremity functional screening tests (Small Knee Bend [SKB], Single Leg SKB, Lunge and Hop Lunge) were related to peak angles during more dynamic/higher load landing tasks (Running and Drop Jump).

METHODS: Data for this paper have been obtained from two of our studies. Twenty five adults (22 ±4 y, 171 ±10 cm, 66 ±12 kg) and twenty three young athletes (11 ±1 y, 153 ±10 cm, 44 ±8 kg) with no musculoskeletal problems volunteered for the studies. A nine camera motion analysis system (Qualysis Medical AB, Sweden) sampling at 240 Hz collected kinematic data. All participants had retro-reflective markers (19 mm diameter) secured to anatomical locations (sacrum, bilateral ASIS's, iliac crests, greater trochanters, medial and lateral femoral epicondyles, mid-patella, medial and lateral malleoli, head of 5th metatarsal, head of 2nd metatarsal, posterior calcaneus) by an experienced musculoskeletal physiotherapist. Four cluster marker sets were attached to the thigh and shank. The anatomical markers were used for construction of a skeletal model using Visual 3D (C-Motion Inc, USA). All participants attended the motion analysis laboratory on one occasion. Following instrumentation of the retro-reflective markers a static standing trial was collected. The order of the functional tests (Table 1) was randomized among participants. For all tests participants were given standardized verbal instructions prior to each test and the researcher demonstrated each test. The SKB, and the Single Leg SKB on each leg, were performed by all participants while the adults only performed the Lunge and Hop Lunge. The young athletes also performed the Drop Jump starting on a 25 cm high box and dropping directly down off the box onto the force plate and immediately jumping vertically as high as possible. All adults were recorded running the length (10 m) of the laboratory and all young athletes were recorded running on a treadmill at self-selected pace. All movement trials were tracked using the Qualysis motion capture software and exported to Visual 3D (C-Motion Inc, USA). In Visual 3D the rigid link model (pelvis, thigh, shank and foot) created from the static file was assigned to all imported motion files to calculate joint angles. All pelvis and lower extremity angles were exported to a customised Labview programme and processed to provide peak joint angles during the loading phase (knee flexion phase) of each clinical functional test and the right and left stance phase (start to maximum knee flexion only) of running. The loading phase in the Drop Jump was from initial ground contact (determined by the force plate recordings based on the onset of the vertical ground-reaction force) to maximum knee flexion. The mean of the three trials for each joint angle for each participant was used in the statistical analysis. Pearson correlation coefficients were calculated to assess the magnitudes of the associations between the clinical functional tests and the drop jump and running. The magnitudes of the correlations were described as trivial (0.0-0.1), small (0.1-0.3), moderate (0.3-0.5), large (0.5-0.7), very large (0.7-0.9), or extremely large (0.9-1.0) (Hopkins, Marshall, Batterham, & Hanin, 2009).

Table 1: Description of the clinical lower extremity functional tests used in the study.

Clinical functional test	Test description
Small Knee Bend (SKB)	Starting from a standing position, participants performed a partial squat (hip and knee flexion) with the trunk maintained in an upright position. Participants were instructed to continue the SKB until they reached maximum dorsiflexion without lifting their heels and then return to upright standing.
Single Leg SKB	Standing on one leg, with the contralateral hip in neutral and knee flexed to approximately 80°, participants performed a SKB as described above.
Lunge (dominant leg)	From a standing position participants were instructed to lunge forward (leading with their dominant leg) a distance of approximately one and a half times the length of their normal gait stride. As they moved into single leg stance (on the dominant leg, with the contralateral leg off the ground) they flexed the hip and knee while maintaining an upright trunk. Participants were instructed to continue the lunge until reaching maximum dorsiflexion of the stance leg without lifting their heel.
Hop Lunge (dominant leg)	From a standing position participants were instructed to jump forward a distance of approximately 1.0 m and on landing on the dominant leg to flex the hip and knee. Participants were instructed to continue the lunge until reaching maximum dorsiflexion of the dominant leg without lifting their heel.

RESULTS AND DISCUSSION: For the twenty five adult participants Pearson correlation coefficients were moderate to very large between the peak ankle, knee and hip angles recorded during the clinical functional tests and those recorded during running (r=0.53 to 0.93; Table 1). The strongest correlations (r ≥0.70) for three or more clinical functional tests existed for ankle eversion, knee abduction, hip abduction and hip internal rotation. The confidence limits for the majority of ankle, knee and hip correlations indicated the true correlations were very likely to be at least moderate (≥0.3) and likely to be large (≥0.5). The correlation for peak pelvic lateral tilt was also high (r=0.60 to 0.72).

In the young athletes there were also large to very large correlations between peak hip, knee and ankle angles during the SKB and the Drop Jump (r=0.57 to 0.87; Table 2). Hip internal rotation showed the strongest correlations (r=0.82 and 0.87). Confidence limits indicated the true correlations were very likely to be at least moderate (≥0.3) and possibly large (≥0.5). There were also moderate to very large correlations between peak hip, knee, ankle angles during the Single Leg SKB and those recorded during the loading phase of running (r=0.45 to 0.84; Table 3).

Table 2: Associations (for 25 adults) between peak joint angles during the Small Knee Bend, Single Leg SKB, Lunge and Hop Lunge and Running (expressed as Pearson correlation coefficients).

		SKB	Single Leg SKB	Lunge	Hop Lunge
Ankle	Eversion	0.77	0.76	0.60	0.79
Knee	Abduction	0.70	0.70	0.79	0.66
Hip	Adduction	0.80	0.73	0.75	0.71
	Internal rotation	0.90	0.89	0.87	0.85
Pelvis	Lateral tilt	0.71	0.60	0.65	0.64

Pearson correlation coefficient 0.1 90% CL~±0.33, 0.6 90% CL~±0.22, 0.9 90% CL~±0.7.

Table 3: Associations (for 23 young athletes) between peak joint angles during the Small Knee Bend and Drop Jump and between the Single Leg SKB and Running expressed as Pearson correlation coefficients (90% CL).

		Small Knee Bend versus Drop Jump		Single Leg SKB versus Running	
		Right leg	Left leg	Right leg	Left leg
Hip	Adduction°	0.61 (0.33-0.79)	0.57 (0.27-0.77)	0.45 (0.10-0.70)	0.57 (0.24-0.79)
	Internal rotation°	0.82 (0.65-0.91)	0.87 (0.74-0.93)	0.46 (0.12-0.70)	0.67 (0.39-0.84)
Ankle	Eversion°	0.71 (0.46-0.85)	0.66 (0.39-0.82)	0.78 (0.56-0.90)	0.65 (0.35-0.83)
Knee	Abduction°	0.60 (0.32-0.79)	0.63 (0.36-0.81)	0.64 (0.36-0.81)	0.84 (0.68-0.93)

These results show that for many of the variables of interest there is a moderate to strong association suggesting that participants with higher peak angles in the clinical lower extremity functional screening tests also had higher peak angles in running and landing from a jump. This association provides some preliminary support for the use of these clinical tests as a screening tool for lower extremity movement/dynamic alignment. If an athlete has a current injury that prevents the use of a high load test such as a drop jump or running, an indication of alignment/control can still be gained via the use of clinical functional tests. Additionally there are advantages involving space and equipment which make the use of clinical functional tests such as the Single Leg SKB more feasible than direct assessment of running gait. We caution that we are not suggesting the clinical functional screening tests can take the place of drop jump or running assessment. We have not performed a comparison of kinematics throughout (or at specific time points during) these functional tests, drop jump and running, which would be required before this could be contemplated. Furthermore we are not suggesting screening using clinical lower extremity functional tests replace more detailed clinical or biomechanical assessment but that they are considered complementary and useful in certain situations.

CONCLUSION: There were moderate to large associations between the lower extremity peak angles during clinical lower extremity functional tests (SKB, Single leg SKB, Lunge and Hop lunge), and angles during more dynamic/higher load running and drop jump landing tasks. Based on these results these clinical functional screening tests should be useful in helping practitioners screen lower extremity movement/dynamic alignment in healthy adults and young athletes.

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