P03-10 ID200

DO FLEXIBILITY SCREENING TESTS REFLECT JOINT RANGE OF MOTION DURING DYNAMIC TASKS?

Laura-Anne M. Furlong, Andrew J. Harrison

Biomechanics Research Unit, University of Limerick, Limerick, Ireland

The aim of this study was to investigate if ankle joint range of motion (ROM) during a functional screen test was related to ankle ROM and plantarflexor reactive strength index (RSI) during a dynamic task. The three measures were correlated for the dominant and non-dominant legs to identify what relationship, if any, existed between the three measures. Results showed that there was no relationship between the two measures of ROM, and ROM during the sledge task was positively related to plantarflexor RSI. This is in contrast to other work, possibly due to the isolation of the plantarflexor muscles in the sledge task. Interestingly, between-leg relationships were lower in the dynamic task, suggesting increased variability in the movement strategies used or underlying training differences.

KEY WORDS: stretch-shortening cycle, stiffness, musculotendinous mechanics, games players

INTRODUCTION: Functional movement screening (FMS) has seen an increase in popularity in recent years due to reported associations between high FMS scores and reduced risk of injury in longitudinal prospective studies. Chorba *et al.* (2010) reported a large correlation ($r = 0.73$, $p < 0.05$) between previously healthy basketball players scoring less than 14 in Cook's FMS and risk of musculoskeletal injury in basketball players. One of the key aspects of this battery of tests is study of the joint range of motion (ROM) which is partly affected by the extensibility of the musculotendinous structures surrounding a joint (Witvrouw *et al.*, 2003). While these screening tests guide to the presence of limitations in a joint's ROM and potential areas of muscle tightness (Kritz *et al.*, 2009), questions must be asked about the ecological validity of these tests in relation to what occurs during dynamic, sports-specific tasks (Okada *et al.*, 2011). The first aim of this study was hence to establish what relationship, if any, existed between the commonly used measure of ankle active ROM in a non-weight bearing (non-WB) position and ankle active ROM in a dynamic stretch-shortening cycle (SSC) task isolating the ankle joint.

Flexibility is a measure of the extensibility of the musculotendinous structures surrounding a joint and may be limited by bony restrictions, location of muscle or fat mass and movement demands. It has sometimes been incorrectly suggested to reflect system stiffness, which refers to the ratio of force to elongation of tissue. The reactive strength index (RSI) is a measure of the effectiveness of the (SSC) of a particular muscle group, and is normally associated with increased system stiffness (Harrison *et al.*, 2004) The second aim of this study was to establish if ankle joint ROM in the non-WB position or the dynamic task was related to measures of plantarflexor RSI. The results of this study may help to guide practitioners in selection of appropriate, specific screening tests to aid in reducing possible injury risk.

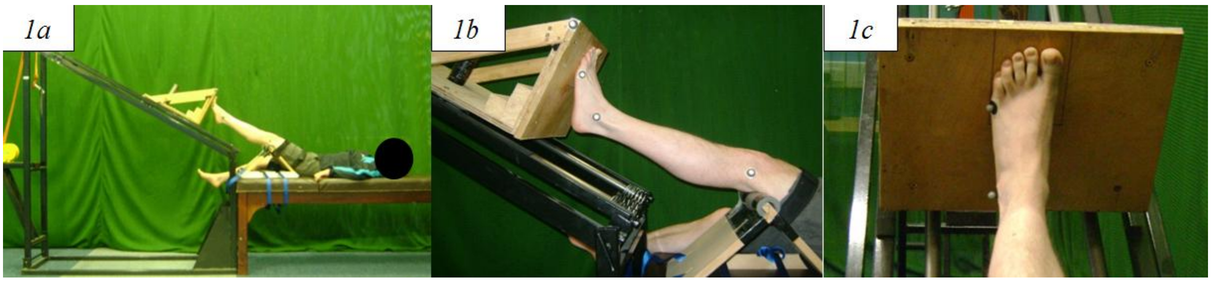
METHODS:

Participants: Following university ethics committee approval, twenty healthy subjects gave written informed consent to participate in this study (age: 23.5 ±2.30 years, mass: 74.2 ±11.51 kg, height: 1.73 ±0.075 m). None had a history of lower limb surgery and all were injury free in the lower limb for the preceding 3 months.

Test protocol: The dominant leg was defined as the preferred hopping leg due to the nature of the dynamic task. For all subjects, this was also the preferred kicking leg. Ankle ROM was determined with the subjects in a prone position and the knee at 90º. All angles were measured using a biomedical gravity-based inclinometer with the inclinometer positioned on a flat piece of plastic running from the toes to the heel of the subject's foot for each trial to ensure between-subject protocol reliability. The inclinometer was zeroed when the subject felt that their foot was in a neutral position so all angles were established relative to their own zero. Subjects were asked to pull their toe as far towards their knee (dorsiflexion) and towards the ceiling (plantarflexion) as possible for five trials, with joint angle recorded when the maximum movement in each direction was reached. ROM was the sum of the maximum plantarflexion and dorsiflexion angle in each direction.

A similar methodology to Furlong and Harrison (2013) was used in this study to establish joint ROM during the dynamic task. 12 mm retro-reflective markers were placed on the sledge plate edge and the subject's knee joint centre (KJC), lateral malleolus (MALL) and lateral 5th metatarsophalangeal joint (5MTP) for tracking by a six camera 3D motion analysis system (500 Hz, MAC Eagle, Motion Analysis Corporation Inc., Santa Rosa, CA., USA). These markers were used to define the ankle angle.

Subjects were positioned supine at the base of the sledge as shown in figures 1a, 1b and 1c and the thigh of the tested leg was secured using Velcro straps. Subjects were instructed to strike the plate as rhythmically as possible while minimising plate contact time, using only their ankle joint. Familiarisation consisted of a total of approximately 25-30 impacts with no added mass where the subject initially pushed the plate away from them and struck it rhythmically and a second trial where the plate was released from 30 cm away from the foot. The protocol continued until the subject was satisfied that they were familiar with the task and the researcher deemed the subject was striking the plate as instructed. The same instructions were used for the test protocol. After successful completion of a trial, the plate was secured away from the foot and additional mass was added to the sledge. The test was administered similar to an 11 repetition maximum strength test, with the researcher attempting to reach the maximum loading in as short a time frame as possible. A loading of 70% of this 11RM has been shown to be the most reliable loading therefore trials at this loading were used for analysis (Furlong & Harrison, 2013).



Figures 1a-c. Force sledge set-up. 1a) shows the full sledge set-up with subject secured in place. 1b) shows the motion analysis marker positions on the fifth metatarsophalangeal joint, lateral malleolus and knee joint centre, and 1c) shows the marked area which subjects were instructed to strike as rhythmically and continuously as possible.

Data treatment: Residual analysis was conducted to identify what was the optimum cut-off frequency to ensure the signal: noise ratio was balanced. Marker position data was filtered using a fourth order, zero lag, low-pass Butterworth filter with cut-offs of 12, 12, 14 and 18 Hz for the sledge, 5th MTP, MALL and KJC markers respectively. Plate acceleration was calculated as the second derivative of plate position with respect to time, with force calculated using Newton's second law with a correction for the component of weight acting down the sledge rails since the sledge was angled at 30°. Frictional force was negligible (0.19%) so was omitted from the calculation. Contact time (CT) was defined as the period when plate marker acceleration was greater than zero and flight time (FT) defined as the period when it was zero or less. Joint ROM was defined as the maximum angle reached by the joint during CT minus the minimum angle reached during CT.

Data analysis: Based on previous work, only the middle impacts (4 to 8) were used for analysis. The average of the five trials of both ROM and RSI were used for input into the statistical analysis. All analysis was completed in SPSS Statistics 19 (IBM, Armonk, NY, USA). Pearson's correlation was used to determine what relationship, if any, existed between the measures of ROM and reactive strength index of the dominant and non-dominant legs. The r critical for 18 degrees of freedom and $p < 0.05$ (two-tailed) was 0.44, therefore correlations of lower than 0.44 were considered to accept the null hypothesis.

RESULTS: Results are shown in table 1. There was no relationship between the ROM measured using inclinometry and measured during the dynamic task (0.312 in the dominant leg and 0.141 in the non-dominant leg). There were moderate and small significant relationships between the ROM during the dynamic task and plantarflexor RSI in the dominant ($r = 0.737$) and non-dominant (0.470) limbs respectively. There were also moderate, significant between-leg correlations for both inclinometry and sledge ROM measures.

Table 3. Pearson's correlation coefficients, showing the relationship between the range of motion obtained during non-weight-bearing activity (non-WB ROM), dynamic activity on a force sledge (sledge ROM) and plantarflexor reactive strength index (PF RSI). ** denotes p< 0.01; *denotes p< 0.05.

		Dominant leg			Non-dominant leg		
		Non-WB ROM	Sledge ROM	PF RSI	Non-WB ROM	Sledge ROM	PF RSI
Dominant	Non-WB ROM	1					
	Sledge	.312	1				
	PF RSI	.273	.737**	1			
Non-dominant leg	Non-WB ROM	.735**	.192	.360	1		
	Sledge	.044	.617**	.555**	.141	1	
	PF RSI	-.138	.483*	.721**	.006	.470*	1

DISCUSSION: The results of this study show no relationship between ankle active ROM in a non-WB position and ankle active ROM in a dynamic SSC task isolating the ankle joint. These results raise questions in relation to the validity of the use of functional screen tests and flexibility testing during tasks that do not replicate the demands of the sport in question. Further research into the relationship between ROM observed during screening protocols and other dynamic, sport-specific tasks is necessary however to provide further evidence of this. Of interest, there was a smaller relationship between the two measures in the non-dominant leg, possibly due to increased variability in the strategies used to generate force in the non-dominant leg or underlying training-related differences.

There were high between-leg correlations for both inclinometry and sledge ROM measures, which is expected for a between-leg comparison in healthy individuals. Higher correlation was seen in the inclinometry trials. Inclinometry trials are controlled and slow-paced so a similar movement strategy can be used during the test in both legs. This results in correspondingly high test reliability (Russell *et al.*, 2010). In contrast, during the dynamic task the subject may use a number of different strategies to generate the same force output. Again, part of these differences may be due to underlying training differences.

There was a high correlation between the measures of sledge ROM and RSI. In contrast to previous work which reported a negative relationship between ROM and RSI, table 1 shows increased ROM results in increased RSI. This may be due to a number of reasons. Subjects were instructed to strike the plate as quickly as possible but also to try to maximise plate height. To do this, subjects will utilise a greater ROM to allow themselves more time to generate force in the eccentric phase. Previous work has also examined the lower limb as a whole, rather than just the plantarflexors in isolation.

CONCLUSIONS: There is no relationship between measures of ankle joint ROM during non-weight bearing inclinometry and dynamic, sledge testing. Further research is required into the relationship between ROM observed during functional screening and dynamic, sport-specific tasks to determine the ecological validity of the screening protocols. A relationship between the ROM during the sledge task and the RSI of the plantarflexors was also observed which is greater in the dominant than non-dominant legs, possibly due to training differences.

REFERENCES:

Chorba, RS, Chorba, DJ, Bouillon, LE, Overmeyer, CA, & Landis, JA. (2010). Use of a functional movement screening tool to determine injury risk in female collegiate athletes. *North American Journal of Sports Physical Therapy, 5*(2), 47-54.

Furlong, LAM, & Harrison, AJ. (2013). Reliability and consistency of plantarflexor stretch-shortening cycle function using an adapted force sledge apparatus. *Physiological Measurement, 34*(4), 437-448.

Harrison, A. J., Keane, S. P., & Coglan, J. (2004). Force-velocity relationship and stretch-shortening cycle function in sprint and endurance athletes. *Journal of Strength and Conditioning Research, 18*(3), 473-479.

Kritz, M, Cronin, J, & Hume, P. (2009). The bodyweight squat: A movement screen for the squat. *Strength and Conditioning Journal 31*(1), 76-85.

Okada, T, Huxel, KC, & Nesser, TW. (2011). Relationship between core stability, functional movement and performance. *Journal of Strength and Conditioning Research, 25*(1), 252-261.

Russell, JA, Kruse, DW, Nevill, AM, Koutedakis, Y, & Wyon, MA. (2010). Measurement of the extreme ankle range of motion required by female ballet dancers. *Foot and Ankle Specialist, 3*, 324-330.

Witvrouw, E, Danneels, L, Asselman, P, D'Have, T, & Cambier, D. (2003). Muscle flexibility as a risk factor for developing muscle injuries in male professional soccer players. *American Journal of Sports Medicine, 31*(1), 41-46.

Acknowledgement:

Funding for this research was provided by an Irish Research Council for Science, Engineering and Technology Embark Scholarship.