LATERALITY AND ITS EFFECT ON LOWER EXTREMITY MUSCULOSKELETAL STIFFNESS IN MALE SOCCER PLAYERS AND TRACK RUNNERS

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The purpose of this study was to determine the influence of laterality on lower extremity stiffness in healthy soccer players and track runners. Eight soccer players aged 15 to 17 years, and eight track runners, aged from 18 to 25 years performed a battery of tests (Single and double legged continuous straight and bent-legged jumping, and running) to determine lower extremity musculoskeletal stiffness. All participants were injury free at the time of testing. Statistical tests of the various all kinetic measures revealed that the track runners were asymmetrical in their musculoskeletal performance qualities, whereas, the soccer players displayed symmetry. Future research should examine lower extremity symmetry in an older group of soccer players, and the development of a training program to alter lower extremity stiffness into a typical range.

KEYWORDS: soccer, track running, stiffness, bilateral, jump

INTRODUCTION:

Movement and its causal neuromuscular activation generate specific loading patterns. Soccer (also more widely known as football) participation can result in the lower limbs experiencing asymmetrical (i.e. hopping and kicking) and symmetrical loading (i.e. locomotion and jumping). This subsequent loading pattern results in the modification of physical characteristics at the musculoskeletal level. These modifications occur as a result of overloading and stressing of the system and particularly occur when the tasks are performed at high velocities. One musculoskeletal characteristic which is modified by repetitive loading is lower extremity stiffness. Lower extremity stiffness is the combined actions of muscles, tendons, ligaments, cartilage and bones and their collective ability to temporarily deform under a given force (Kuitunen, 2002). The importance of lower extremity stiffness in sport is in the storage and re-utilisation of the required spring energy to perform and continue movement. Musculoskeletal stiffness also can be an indicator of injury risk (Bradshaw et al., 2006). Previous research has identified asymmetrical musculoskeletal differences in soccer players (Rahnama et al., 2005). Normally, a soccer player demonstrates a training induced asymmetry in strength favouring the non-preferred leg as a result of the repetitive loading being applied on the opposing, stabilizing leg, during kicking. This causes eccentric or isokinetic strength adaptations to occur. However, it is unknown whether a difference in lower extremity stiffness between legs exists in players from sports which are one-sided dominant (i.e. soccer) where the athlete displays a ‘preferred foot’, in comparison to sports that are cyclical and/or non-sided dominant (e.g. track running).

A preferred foot is the leg used to manipulate an object and/or initiate or lead an action (Sadeghi et al., 2001) such as the lead foot in kicking. The use of a preferred leg often gives rise to musculoskeletal asymmetry and footedness (Rahnama et al., 2005). Asymmetry exists if there is a greater than 10% difference for a specific quality (e.g. force, power, muscle girth) between limbs (Grace et al, 1984). This often influences the overall laterality of the athlete, which is the overall preference of one side of the body over the other (e.g. soccer player displays laterality toward the preferred kicking leg) (Sadeghi et al., 2001). This preference of sides, or laterality, results in a dominance of one limb over the other during specific tasks. A dominant limb generates greater propulsion (mobilises) or displays predominant power capabilities for the execution of a task (Sadeghi et al., 2001). In jumping during a header in soccer, for example, the dominant limb generates the most power for the resulting vertical ascent, whilst the non-dominant limb acts to stabilise the action, thereby keeping the player balanced during the ground contact (loading) phase. Research and clinical assessments of gait commonly combine tests of symmetry, laterality, and dominance with measures of musculoskeletal qualities, neuromuscular activation patterns and sequencing of movement. However this type of multidisciplinary analysis (motor control and biomechanics) does not readily occur in sports performance. The purpose of this study was therefore to examine the relationship between bilateral lower extremity stiffness in dominant and non-dominant sided sport athletes.

METHOD:

Sixteen adolescent and post-adolescent males (age = 18.44 ±3.27 years, stature = 177.5 ±6.3cm, mass = 69.33 ±5.39kg) participated in the study. All volunteers were high-class performers (full-time athletes) comprising of eight national-class junior soccer players (age = 15.75 ±0.71 years, stature = 178.8 ±6.5cm, mass = 70.84 ±6.80kg) matched for stature and mass with eight national class junior and senior track and field runners (age = 21.25 ± 2.12 years, stature = 179.0 ±6.0cm, mass = 71.07 ±6.27kg). All participants were injury free at the time of testing. The criteria for injury was when an athlete had not participated in training for more than 7 days and/or had not participated in two sequential competitions at the time of testing (Noyes et al, 1988). Laterality was determined from the self-reported preferred kicking leg via a questionnaire.

All athletes completed various jumping tests and overground running across two sessions (session one = jumping, session two = running). The multiple jump tests (1 trial/test) included single (left, right) and double legged series of ten straight-legged jumps (CJS) where the hip and knees were systematically braced in an extended position, and single (left, right) and double legged series of ten bent-legged jumps (CJB). During all jumping tasks, participants maintained an upright position with their hands held loosely on the hips throughout. All jumping data was collected using a portable force platform (Quattro, Kistler, Switzerland, 500 Hz). During the second session of testing, participants performed 10 running (Run) trials on a 10 m runway. Five trials of running were performed with the right foot contacting the force platform whilst capturing the right-sided sagittal plane motion, with the remaining five trials recording the left foot kinetics and left-sided sagittal motion. The participants were given as many practice attempts as necessary to become comfortable with the protocol, and ran at their self-selected running pace. The running kinetic data was collected using an AMTI (USA, 1000 Hz) force platform. The whole-body sagittal plane motion (kinematic) data was collected during the ground contact phase on the force platform using a digital video camera (Panasonic AG DVC30, PAL, 50 Hz, 1/500 s). A 1m rod was filmed in a horizontal and vertical position to calibrate the video footage. All force curves collected from the various vertical jumps (CJS and CJB) were analysed using Quattro Jump software (Kistler, Switzerland) and custom written software to obtain the key measures of vertical displacement, peak take–off force, peak take-off power, ground contact time, and lower extremity stiffness (Bradshaw & Le Rossignol, 2004). All forces were normalised to units of body weight (BW) and all power values were normalised to units of W/kg. Running stiffness was measured through kinetic and kinematic techniques using the formula; $F = ks$, where F represents ground reaction force, k represents the vertical stiffness and s represents the vertical displacement of the centre of mass (Hunter, 2003). The vertical position of the body's centre of mass, hip and ankle landmarks were measured from the sagittal plane video of the running trials using Peak Motion Analysis software (Oxford, United Kingdom) with a Butterworth low pass digital filter at 6-8 Hz to determine the change in leg length during the ground contact phase.

Due to the data not meeting normality criteria, non-parametric statistical tests were run in SPSS. To determine the effect of dominance a Wilcoxon Signed Ranks test (non-parametric version of t-test) was performed. This compared each individuals preferred leg against the opposing, non-preferred leg for lower extremity stiffness and was done for pooled group, soccer and track running groups. Statistical significance was set at an alpha level of 0.05. A Kruskal-Wallis test for all dependant variables using age as the factor was performed. No difference ($p > 0.05$) across age was found.

RESULTS AND DISCUSSION:

Surprisingly, the soccer players exhibited symmetrical lower extremity musculoskeletal stiffness during the jumping and running tasks, whilst the track runners displayed significant asymmetry when running (Table 1). Due to the cyclic nature of running it was expected that the track runners would reflect no training-induced asymmetries in their lower extremity stiffness. Significant bilateral asymmetry ($p = 0.01$), however, was identified in the track runners. The running task displayed 16.18 kN/m higher leg stiffness in the preferred leg than the non-preferred leg for the track runner group ($p=0.01$). Collapsing individual results into group data to identify symmetry via statistical tests has limitations (Schot et al., 1994). Investigation of the merits of individual patterns highlights these limitations as more than half the soccer players and track runners displayed functional asymmetries (>10%) during the tasks (Table 2).

Table 1. Lower extremity stiffness descriptives in the preferred and non-preferred legs for soccer players as a group and track runners as a group. Significantly different ($p < 0.05$) task labelled *.

		Preferred leg			Non-Preferred leg				
	Task	Med	Min	Max	Med	Min	Max	% Diff	p - value
Soccer	CJS (kN/m)	7.63	6.06	9.52	8.03	5.54	10.07	4.98	0.57
	CJB (kN/m)	6.93	5.39	9.57	7.56	4.99	9.39	8.33	0.50
	Run (kN/m)	21.60	14.02	29.95	20.00	9.80	31.29	7.41	0.48
Track runners	CJS (kN/m)	11.58	6.15	17.49	12.13	5.09	15.90	4.53	0.89
	CJB (kN/m)	11.47	6.58	18.88	11.19	7.46	17.52	2.44	0.67
	Run(kN/m)	35.58	14.81	57.25	19.40	10.27	26.88	45.47	0.01*

A small number of research studies have demonstrated no training induced asymmetries in musculoskeletal measurement in athletes from preferred leg sports (Maupas et al., 2002). Investigations into laterality also suggest that symmetry exists in young soccer players due to their lack of development. When children become more selective and specialized in their activities they begin to develop increased muscle strength in relation to their natural limb preference (Capricana et al., 1992). Activities practiced at training may direct focus upon the equal use of both feet therefore negating any training-induced asymmetries (Capricana et al., 1992). However, in the high performance players of the current study, it can be speculated that this may not be the reason for our indication of symmetry in soccer players, but due to their greater exposure to regular training and match play. The soccer players in this study were drawn from the same sample (squad) of the population, possibly adapting to the same training induced responses, and may not accurately reflect and represent results of a broader sample of soccer players. These results, therefore, should be interpreted with caution. The results for the track runner group are difficult to explain due to the paucity of research regarding symmetry in runners. It is suggested that deviations in symmetry are indications of inefficiency in metabolic processes (Manning & Pickup, 1998). Hormones and stress levels have also been shown effect soft tissue symmetry (Manning et al., 1996). It can be speculated that higher hormone, stress and metabolic levels can be found in the track running group; nonetheless, we did not test these physiological parameters in this study. Leg functionality could also be an explanation for asymmetry in tasks. Gait research has suggested that propulsion is controlled by the preferred leg and control and support the by the non-preferred leg (Sadeghi et al., 1997). It can not be explained why asymmetry was present only in the Run task and not all tasks (CJS and CJB).

Table 2. Individual lower extremity musculoskeletal stiffness data during all tasks (CJS, CJB, Run) in the preferred (Pref) and non-preferred (Non-pref) leg. Percentage difference between legs (% Diff) was reported and asymmetry (>10% difference between legs) labelled *.

		CJS Task			CJB Task			Run Task		
	Stiffness (kN/m)	Pref	Non-Pref	% Diff	Pref	Non-pref	% Diff	Pref	Non-Pref	% Diff
Track	1	11.6	11.14	3.97	13.26	9.57	27.83*	34.09	19.4	43.09*
runner	2	9.36	12.91	37.93*	8.28	7.51	9.30	39.68	22.65	42.92*
	3	10.59	9.4	11.24*	18.88	17.52	7.20	31.67	19.46	38.55*
	4	6.15	5.09	17.24*	9.05	8.81	2.65	14.81	10.27	30.65*
	5	16.77	15.9	5.19	9.08	12.03	24.52*	24.09	15.19	36.94*
	6	17.49	13.64	22.01*	13.64	15.65	12.84*	57.25	26.88	53.05*
	7	12.41	14.7	15.58*	6.58	7.46	11.80*	36.89	17.46	52.67*
	8	8.32	14.28	41.74*	13.03	11.01	15.50*	46.21	23.94	48.19*
	Group Median	11.10	13.28	16.41*	11.06	10.29	12.32*	35.49	19.43	43.01*
Soccer	9	6.06	5.54	8.58	5.7	5.7	0.00	24.2	16.89	30.21*
	10	7.23	10.07	28.20*	6.03	8.5	29.06*	29.95	17.42	41.84*
	11	9.52	8.55	10.19*	9.53	8.78	7.87	16.68	9.8	41.25*
	12	7.61	9.5	19.89*	7.49	9.39	20.23*	21.23	22.2	4.37
	13	8.46	7.24	14.42*	5.59	8.78	36.33*	26.7	31.29	14.67*
	14	6.28	5.99	4.62	5.39	4.99	7.42	14.95	25.74	41.92*
	15	6.83	8.3	17.71*	6.12	8.07	24.16*	25.13	19.66	21.77*
	16	9.07	9.1	0.33	9.57	6.29	34.27*	14.02	17.02	17.63*
	Group Median	7.42	8.43	12.31*	6.08	8.29	22.20*	22.72	18.54	25.99*

CONCLUSION:

Bilateral lower extremity musculoskeletal stiffness may not indicate asymmetry in young players in a one-sided dominant sport. Track runners indicate bilateral lower extremity musculoskeletal stiffness asymmetry; however future research should include factors which influence this asymmetry. Future research directions should include the use of older soccer players, and possibly players from a different one-sided dominant sport (e.g. Hockey).

Longitudinal monitoring of athletes to provide information on the changes in stiffness over time may also be considered.

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