Back Pain in Rowing; An Evolution of Understanding

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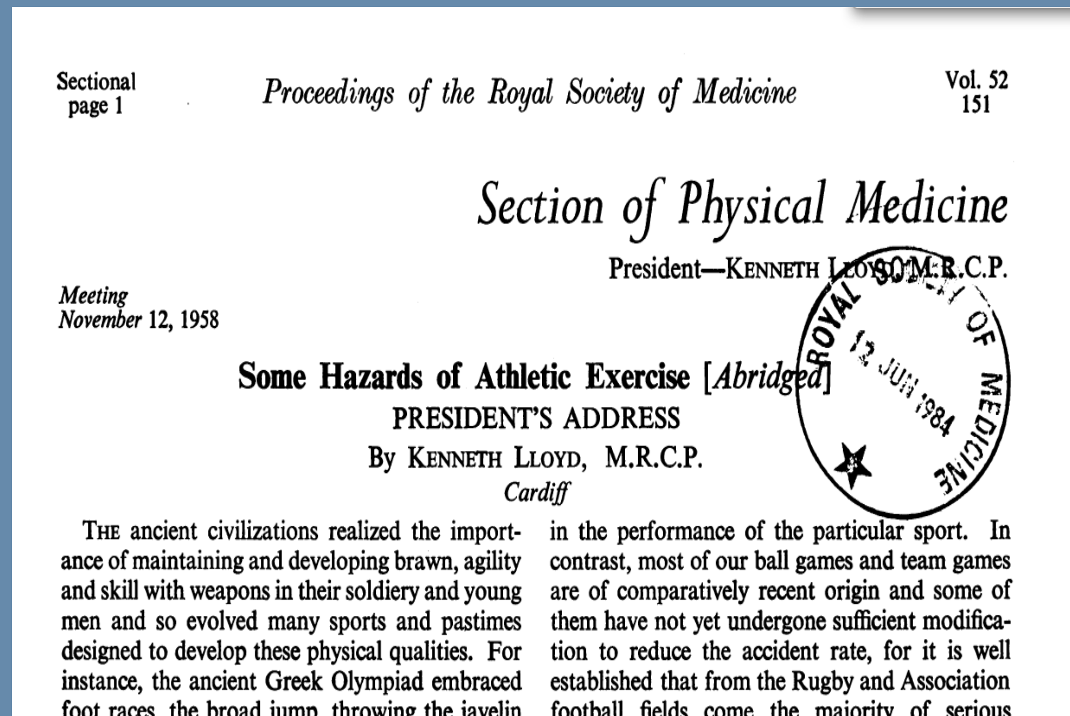
An introduction

- Assistant Professor, School of Medicine, Trinity College Dublin
- Chartered Physiotherapist with over 25 years postgraduate experience
- Chief Physiotherapist Rowing Ireland 1996-2005
- Researcher specializing in rowing LBP, rheumatology and sports medicine
- Book editor, Associate editor for a number of MSK and sports medicine journals
- Cochrane Fellow
- Physiotherapist South Africa Rowing Team
- Ex rower in UK, South Africa and Ireland

The Evolution?

Unclear when rowing LBP first reported but Lloyd[1] first reported 'backache' in 50% of rowers (2 of 4 athletes!) during the British Empire and Commonwealth Games of 1958. Otherwise reporting rowing as 'relatively unhazardous'.



Sectional page 1 — *Proceedings of the Royal Society of Medicine* — Vol. 52 151

Section of Physical Medicine

President—KENNETH LLOYD, M.R.C.P.

Meeting *November* 12, 1958

Some Hazards of Athletic Exercise [*Abridged*]

PRESIDENT'S ADDRESS

By KENNETH LLOYD, M.R.C.P.

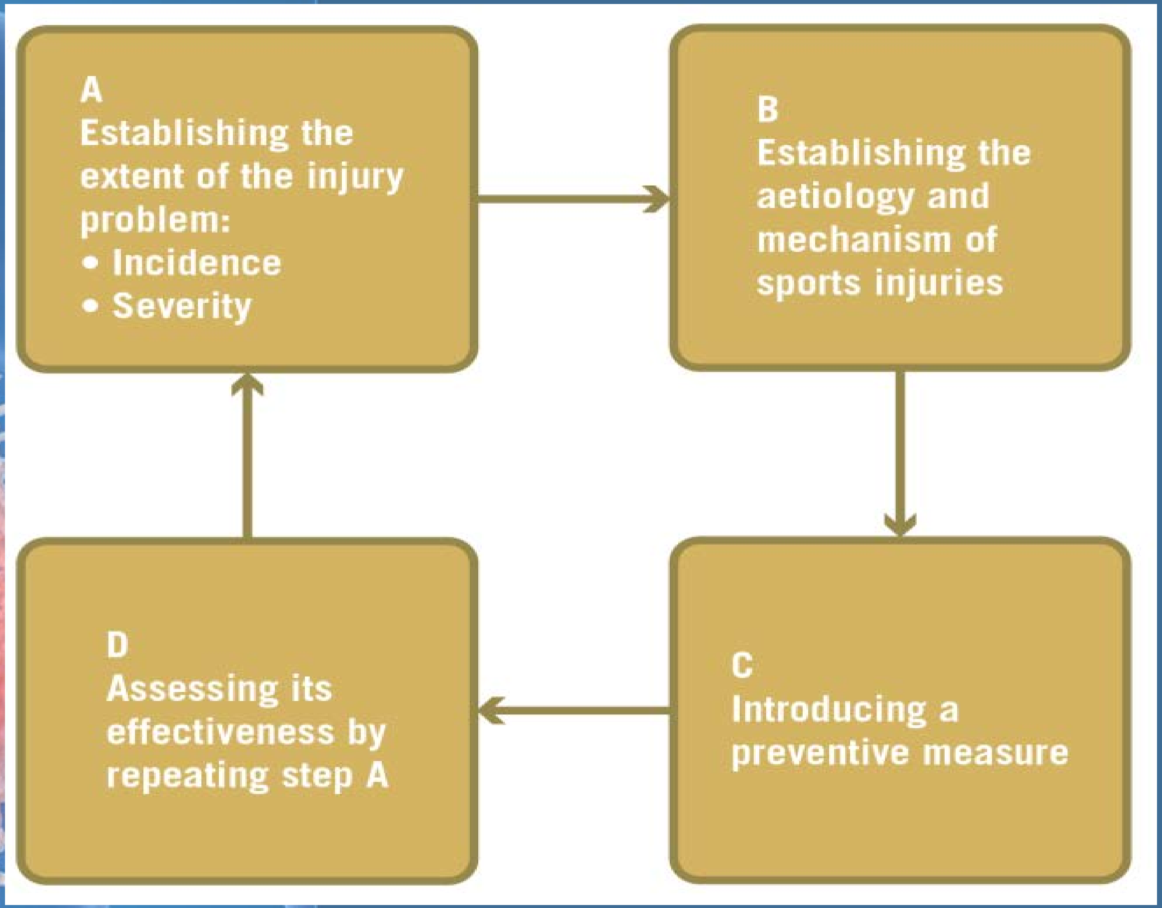
Cardiff

THE ancient civilizations realized the importance of maintaining and developing brawn, agility and skill with weapons in their soldiery and young men and so evolved many sports and pastimes designed to develop these physical qualities. For instance, the ancient Greek Olympiad embraced foot races, the broad jump, throwing the javelin in the performance of the particular sport. In contrast, most of our ball games and team games are of comparatively recent origin and some of them have not yet undergone sufficient modification to reduce the accident rate, for it is well established that from the Rugby and Association football fields come the majority of serious

ROYAL SOCIETY OF MEDICINE 12 JUN 1984

The Evolution?

- 2014, BJSM publishes first issue specializing in rowing medicine



What stage of evolution?

Lack of emphasis on basic epidemiology?

Better development of understanding aetiology and mechanisms?

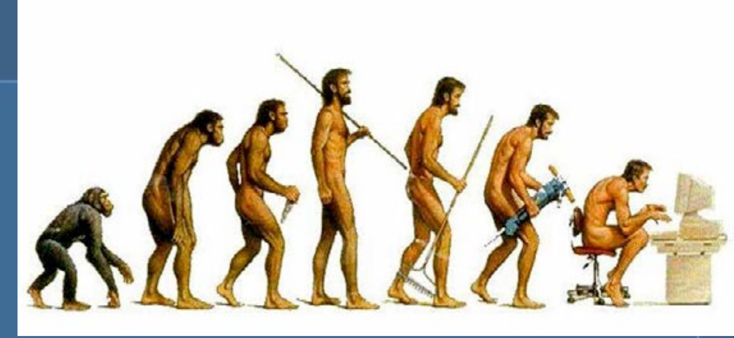
Lack of translation from lab to water?

Preventive measures based largely on clinical intuition?

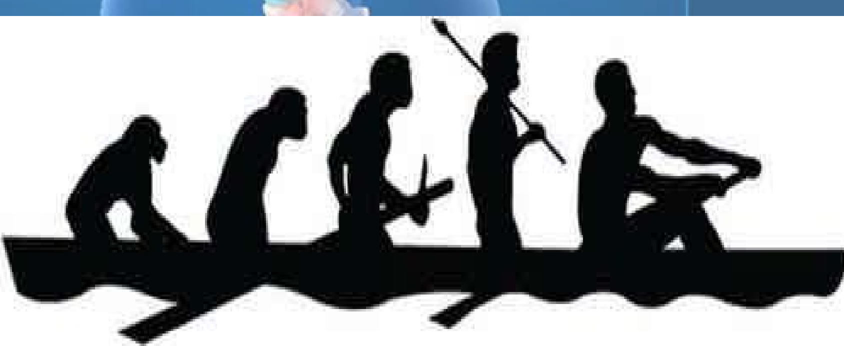
Low back pain in context

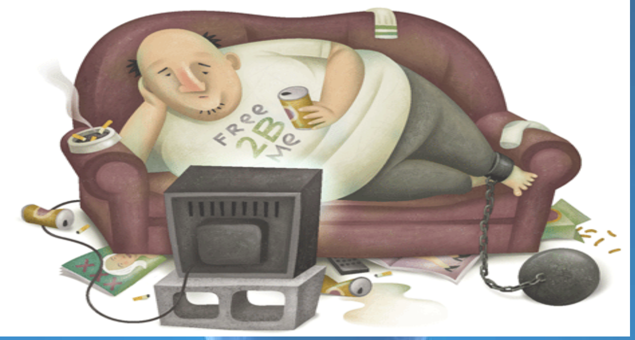
- Low back pain is ranked as the greatest contributor to global disability with a global point prevalence of 9.4% (Western Europe 15%)[2]
- 12-month incidence ranges from 18.4%[3] to 3-5%[4] depending on definition.
- Risk factors include gender, occupation (including lifting), obesity, smoking, socioeconomic factors, physical activity and *lifestyle.*

Rowing or LBP evolution?



- LBP is the most common MSK injury – is the experience in rowing significant?
- Understanding of LBP has evolved with increasing (?) incidence/prevalence. This appears to confirm the issue is very complex
- Great evolution in rowing in recent years in equipment, training volumes and type.
- Introduction of biopsychosocial model of LBP in last 20 years





Is rowing different?

- Lack of confounding variables including smoking, obesity and inactivity
- With evolution of rowing training and equipment, there has also been comparable evolution of support services and rehab (including medical investigation techniques)
- There is a developing ethos of maintaining athletes rather than simply ‘repairing’ them
- But…. there is a challenge in accessing rowing research as sports medicine journals focus on commercial interests

Rowing injury epidemiology; what do we know?

- Two studies (only) report injury incidence as 1.5 and 3.67/1000 hrs
- Lumbar spine is most commonly reported injury site ranging from 2.4% (of all sports) to 51% of injuries
- Of studies that reported 12 month incidence, LBP ranged from 32 to 51% of the surveyed cohort[5]

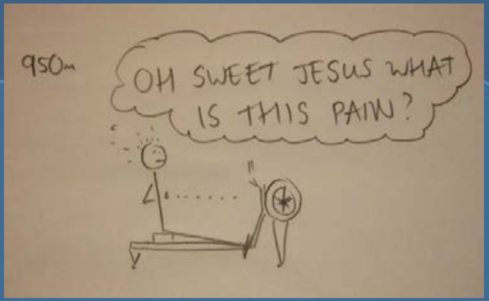
Ergometer training volume and previous injury predict back pain in rowing; strategies for injury prevention and rehabilitation

Fiona Wilson,[1] Conor Gissane,[2] Alison McGregor[3]

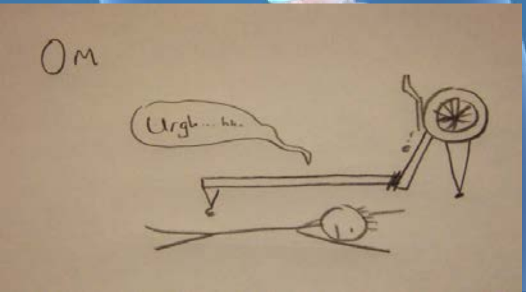
Table 1 Summary of prospective and retrospective studies examining injury in rowers

Authors	Type of study	Sample size	Participants	Severity of injury measured?	Training and competition exposure measured?	Injury rate / 1000 h	Injuries classified?	Mechanism of injury reported?	Most common injury site	Factors associated with injury onset
Deveraux and Lachman[5]	Prospective survey of clinic attendance, 2 years	1186	Recreational athletes	No	No	Not measured	Yes	No	Lumbar spine (2.4% of total)	Not measured
Budgett and Fuller[2]	Retrospective survey of all injuries, 1 year.	69	International male rowers	Yes	Training estimated	0.4 (rowing) 4 (land)	Yes	Yes	Lumbar spine (51%)	Weight training
Reid *et al*[7]	Retrospective survey of clinic attendance, 4 yrs	275	International female rowers	No	No	Not measured	Yes	Yes	Lumbar spine (25%)	Time of year and weight training
Boland and Hosea[3]	Retrospective survey of all injuries, 3 years.	180	College male rowers	No	No	Not measured	Yes	No	Knee (25%)	Not measured
Edgar[10]	Retrospective survey of clinic attendance, 5 weeks	44	International junior rowers	No	No	Not measured	Yes	No	Lumbar spine (30% of total)	Not reported
Coburn and Wajswelner[8]	Retrospective survey of clinic attendance, 1 yr	54	Elite rowers	No	No	not measured	Yes	Yes	Lumbar spine (45% of total)	Weight training
Hickey *et al*[9]	Retrospective survey of clinic attendance, 10 yrs	172	Elite rowers	No	No	Not measured	Yes	Yes	Chest (22.6%) female, Lumbar spine (25%) male	Time of year
Parkkari *et al*[6]	Prospective survey of all injuries, 1 year	3363	General population	Yes	Classed as 'participation time'	1.5, 95% CI 0.6 to 3.9	Yes	Yes	Not reported	Not reported
Smoljanovic *et al*[4]	Retrospective survey of all injuries, 1 year	398	International junior rowers	Yes	Yes	2.1 (training)	Yes	Yes	Lumbar spine (32.3%)	More than 7 training sessions/week
Wilson *et al*[11]	Prospective study of all injuries, 1 year	20	International male and female rowers	Yes	Yes	3.67	Yes	Yes	Lumbar spine (31.8% of total)	Ergometer training load.
Winzen *et al*[12]	Retrospective survey of all injuries, 1 year	67	Elite male and female rowers	No	Yes	Not measured	Yes	Yes	Lumbar spine (50% of interviewees)	Not reported (reported as 'overuse')

Studies examining back pain in rowing

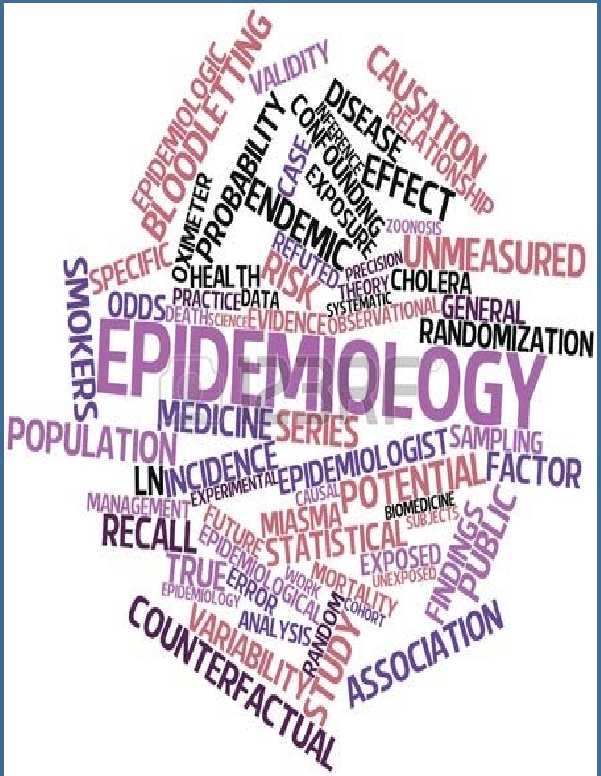


- Bahr et al[6] - 55% of rowers report LBP in 12 months (cf 63% skiing, 49.8% orienteering). Rowers report most missed training & hospitalisation
- Teitz et al[7]- 32% report LBP during college rowing
- Ng et al[8] – point prevalence of 64.5% (males) and 52.8% (females) in adolescent rowers.
- Newlands et al[9] – 53% report LBP in 12 months (1.67/1000 hrs) in the only *prospective study.*



Critique of injury surveillance to date?

- Lack of gold standard prospective studies
- Very limited prospective recording of exposure data so injury predictors (risk factors) can be determined
- Focus of studies on elite or college populations
- No studies of attrition due to LBP
- Interventions studied without reference to epidemiology



Risk factors for LBP in rowing

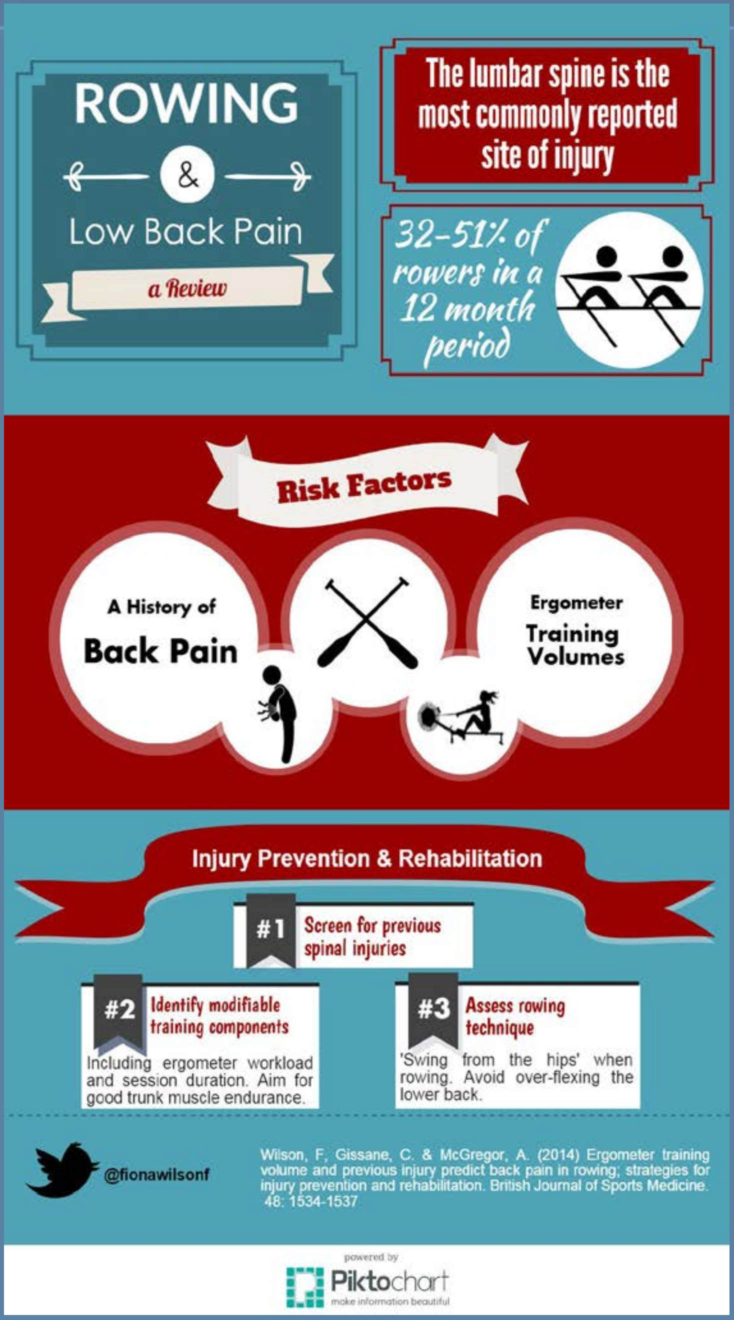
- Previous history of back pain[7,9]
- Ergometer training (particularly sessions lasting longer than 30 mins)[5,7-9]
- Total training hours per month[9]
- Age (increasing with years rowing)[9]

Factors also associated with LBP in rowing

- Core stability training (!!!)
- Time of season (peaking in Winter months)
- Use of hatchet oars
- History of rowing before age 16
- Weight training (particularly free weights)
- More than 7 training sessions/week in juniors
- Older rowers

Summary of risk factors

- ✓*Ergo (more than 30 mins)*
- ✓*History of LBP*



Kinematics

- There is a growing body of work exploring how understanding rowing kinematics can help prevent injury and enhance performance[9-23]
- Research has been laboratory focused with the advantage of controlling many variables
- Small amount of research has taken place on the water allowing a comparison of ergometer and ‘on water’ kinematics

Authors	Subjects	Study protocol	Findings
McGregor et al 2002	20 male elite rowers	Static Interventional MRI Sagittal plane analysis Static analysis of 4 stroke phases	1) Rotation of Lsp into flexion at catch 2) Lsp returns to 'neutral' at finish 3) Lsp held 'upright relative to sacrum at catch
Bull & McGregor 2000	6 male elite rowers	Validation of 'Flock of Birds' against MRI 10 mins rowing at max. effort sagittal plane analysis	1) Fatigue causes increased posterior pelvic tilt throughout stroke, particularly in late drive and finish.
McGregor et al 2005	12 female international rowers	Incremental step test Sagittal plane analysis Flock of Birds	1) Anterior pelvic tilt at catch 2) Anterior tilt decreases at higher ratings 3) Posterior pelvic tilt at finish 4) Greater Lsp flexion and extension with fatigue 5) Relatively less pelvic rotation with fatigue due to altered lumbopelvic rhythm
Caldwell et al 2003	16 male and female school rowers	2000 metre test Sagittal plane analysis Video analysis of reflective markers	1) Fatigue caused lumbar flexion to increase at the catch and mid-drive phase.
Pollock et al 2009	9 female international Rowers	2000 metre test Sagittal plane analysis Motion capture system	1) Pelvic and lumbar segments move from flexion to extension in 1st phase of stroke 2)Motion of the Lsp is minimal during peak force production 3) Most movement seen at L3-S1.
McGregor et al 2007	7 female international Rowers	Incremental step test Sagittal plane analysis Flock of Birds	1) 2 year training trunk endurance improved lumbo-pelvic ratio allowing equal amounts of lumbar and pelvic rotation
Holt et al 2003	13 male elite rowers	1 hour rowing piece Sagittal plane analysis Flock of Birds	1) Significant increase in maximum Lsp flexion and extension with fatigue. 2) Peak force develops significantly later in drive phase with fatigue.
Mackenzie et al 2008	6 male international Rowers	1 hour rowing piece Sagittal plane analysis Flock of Birds	1) Small increase in Lsp flexion at catch and extension at finish (not significant) 2) Subtle increase in anterior pelvic rotation at catch and posterior pelvic rotation at finish
Steer et al 2006	12 male novice rowers	300m rowing piece Sagittal plane analysis Flock of Birds	1) Lsp extension greater on Water Rower 2) Less pelvic anterior rotation at catch on Concept 2 cf Water Rower

Important findings from lab studies

- Specific pattern of lumbo pelvic motion with anterior rotation observed in the pelvis at the catch position and posterior rotation at the finish position
- The lumbar spine rotates into flexion at the catch.
- Fatigue was associated with a change in spinal kinematics; an increase in posterior pelvic tilt and an increase in magnitude of lumbar spine flexion and some studies found an increase in lumbar spine extension
- Studies show large ranges of motion and alteration of movement patterns as a result of fatigue.
- As rowers fatigue, they increase range of movement in their spine and decrease movement in their pelvis as they try to maintain the catch position which is likely to increase loading on the lumbar spine

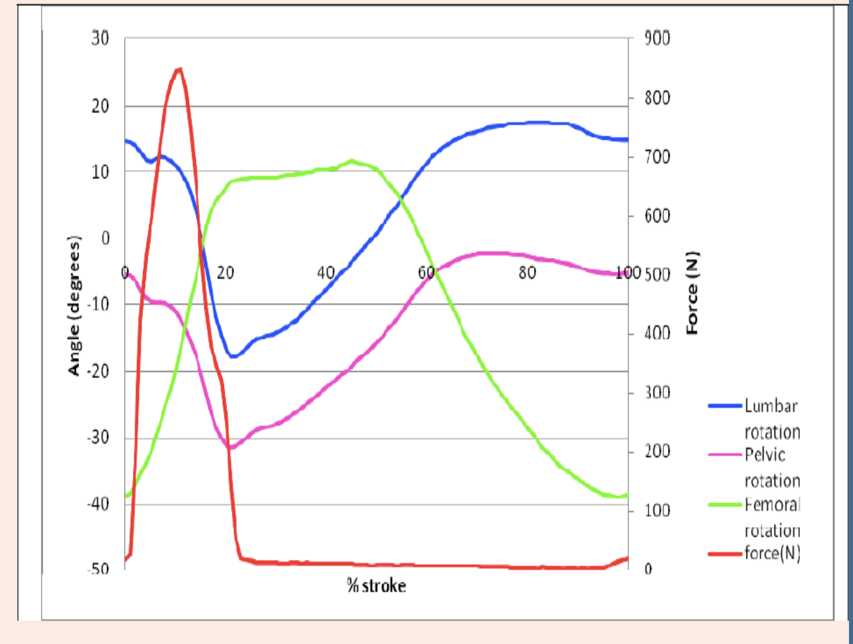


Figure 1. An example of processed data output from one subject taken at the 4th testing interval.

Importance of pelvic position
catch

✔

✗

Importance of pelvic position
finish

✔ ✗

Further information?

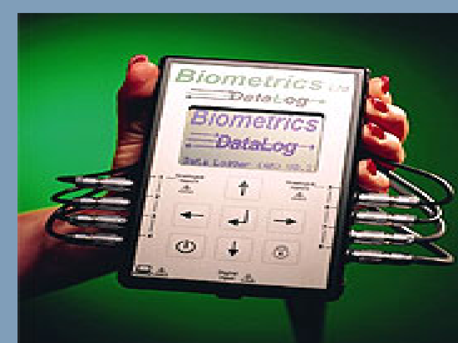
- All studies analysed motion in the sagittal plane in lumbar spine - demonstrates the greatest range.
- Likely that the LSp also moves in both frontal and transverse planes in rowing- reflects normal movement.
- Differences between water and ergometer kinematics have received limited attention- conclusions about boat kinematics should not be inferred from ergometer kinematics.
- Probable that there are greater movements in the frontal plane in the LSp in a boat - expected to be limited on the ergometer.
- None of the equipment used was portable, which may explain why no measurements were conducted in a boat.
-

FRONTAL PLANE MOTION in the LUMBAR SPINE OF ELITE ROWERS

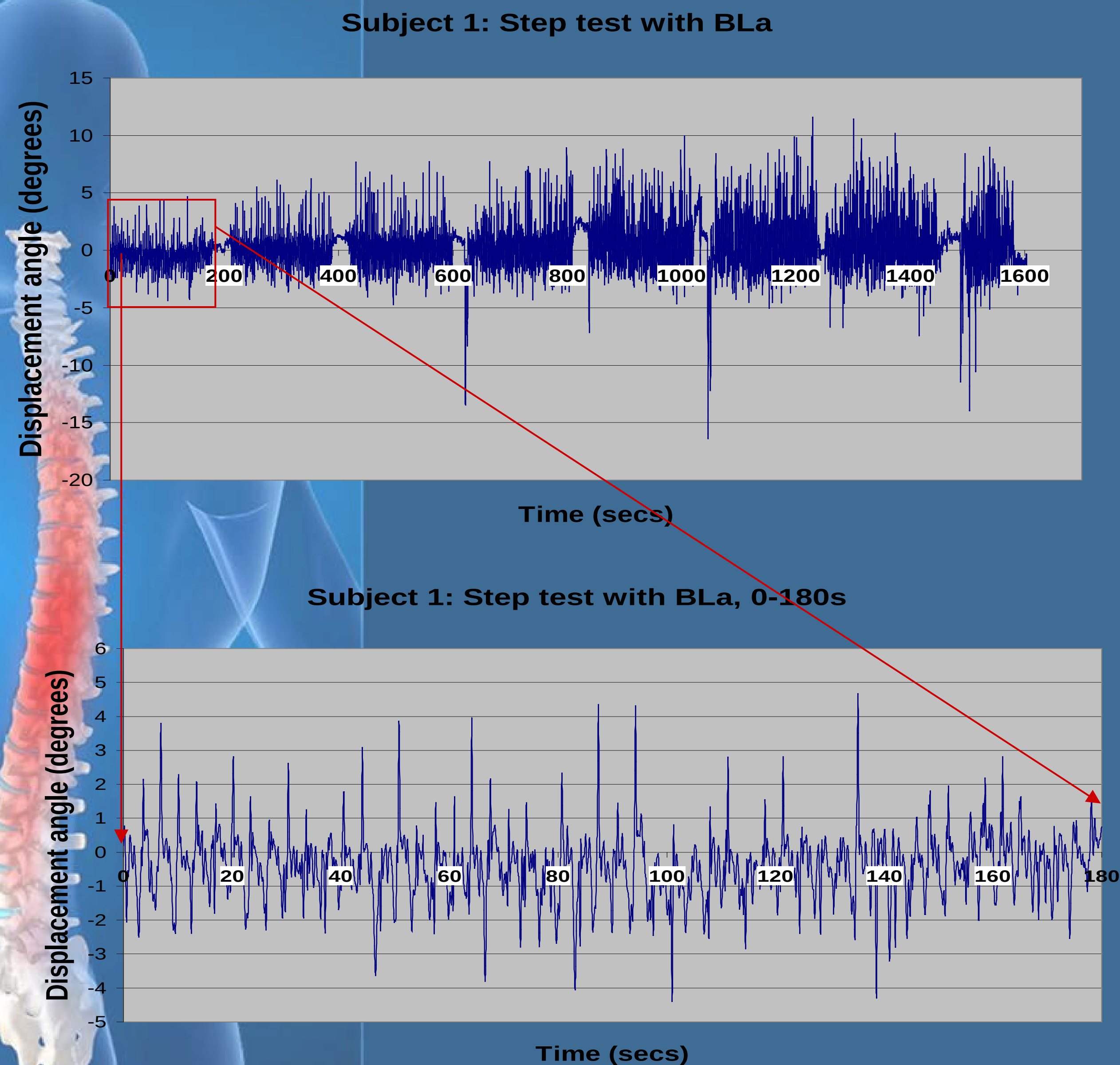
- Analysis of sagittal plane kinematics of the lumbar spine during rowing has noted increased range of motion during prolonged rowing
- The greatest difference in lumbar movement during rowing in a boat compared with ergometer rowing is likely to be seen in the frontal plane although this has not yet been studied.
- Study examined the effects of fatigue (measured by blood lactate accumulation) on changes in angular displacement of the mid-lumbar spine in frontal plane, during ergometer rowing.

Participants	***Instrumentation***	***Protocol***	***Data analysis***
12 senior male rowers, Age 23.2 (SD 5.2) yrs, Mass 79.13 (SD 5.0)kg. Over 18 yrs No history of LSp injury in the previous 6 months.	Spectrotilt RS232 Electronic Inclinometer connected to a Biometrics DataLog. System previously calibrated noting max error of 0.5º.	Inclinometer attached to L3, analysis of frontal plane motion throughout test. Incremental step test on Concept 2 model D ergometer to volitional exhaustion. Blood lactate sampling at every rest period from earlobe using a Lactate Pro portable lactate analyser.	All cycles for first and last step measured . Peak to trough = total frontal plane displacement. First step test compared last step of t using a paired t-test. Alpha was set at P< 0.05. Linear regression analysis of relationship between BLa and displacement.

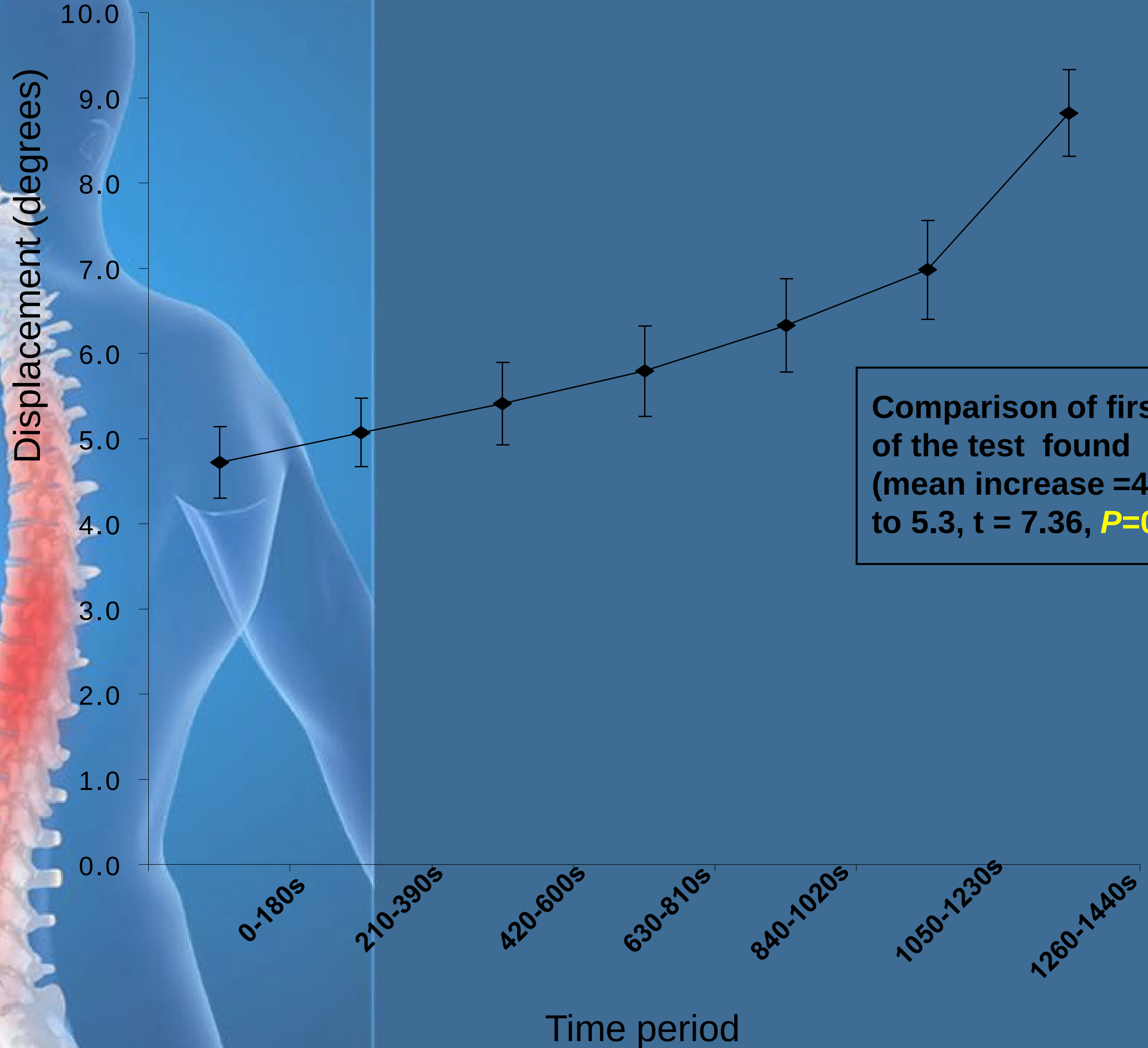
Spectrotilt RS232 Electronic Inclinometer
(*www.spectronsensors.com*



Biometrics DataLog (*www.biometricsltd.com*)



Frontal plane angular displacement during step test with first step magnified (below)



Comparison of first stage and last stage of the test found significant increase (mean increase =4.1 º (1.94), 95% CI, 2.9 to 5.3, t = 7.36, *P*=0.000014).

Mean frontal plane angular displacement (±SD) during the time periods of the test.

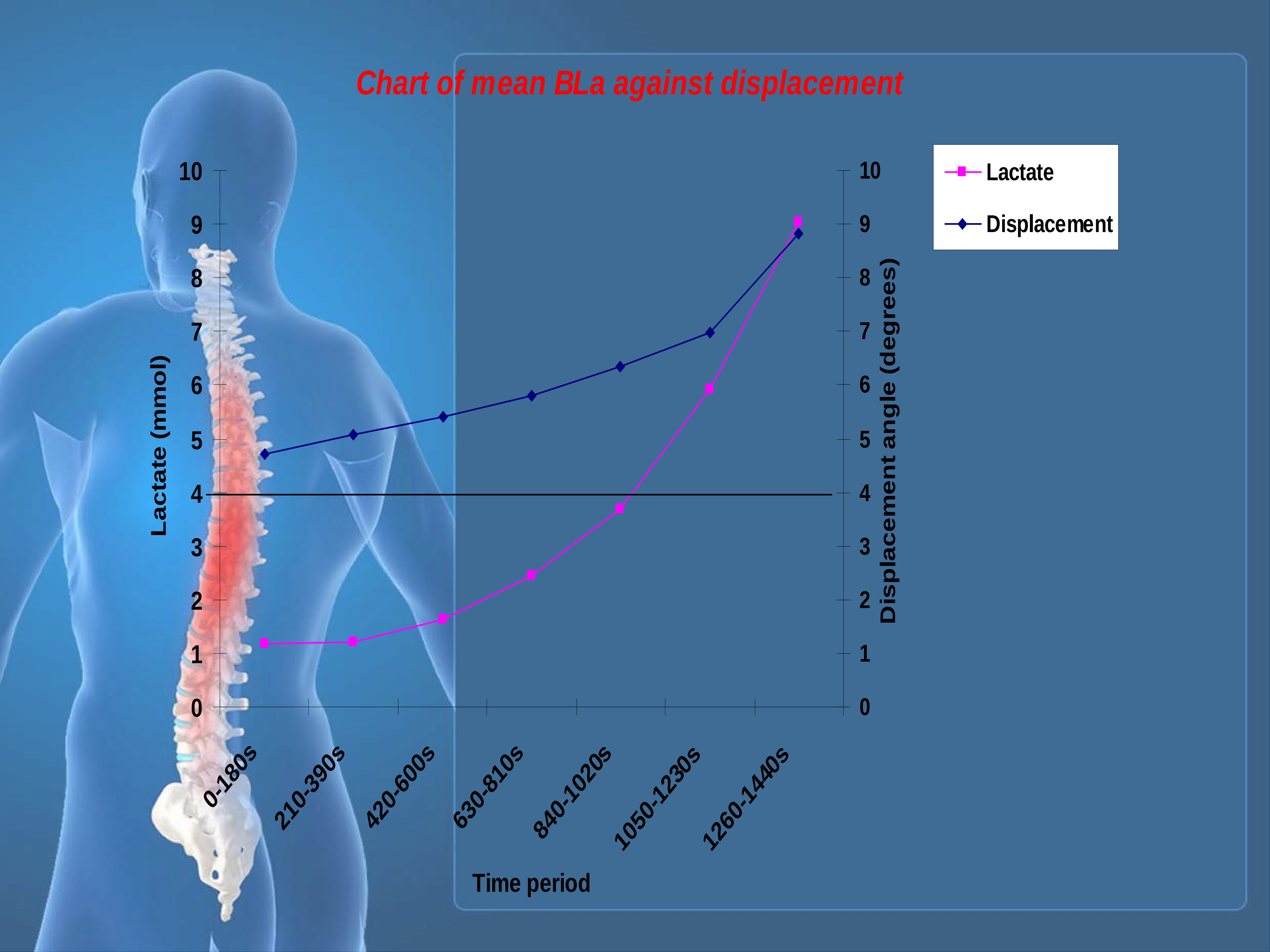


Chart of mean BLa against displacement
Lactate (mmol)
Displacement angle (degrees)
Lactate
Displacement
0
1
2
3
4
5
6
7
8
9
10
0-180s
210-390s
420-600s
630-810s
840-1020s
1050-1230s
1260-1440s
Time period

Regression analysis of variables against spinal angular displacement

Predictor variable	
Lactate	*P*<0.0001, R^2 = 0.24
Stroke rate	*P* = 0.0001, R^2 = 0.335
Stroke rate + lactate	**Only stroke rate is a significant predictor of angular displacement (P=0.001).**

Regression analysis of predictor variables

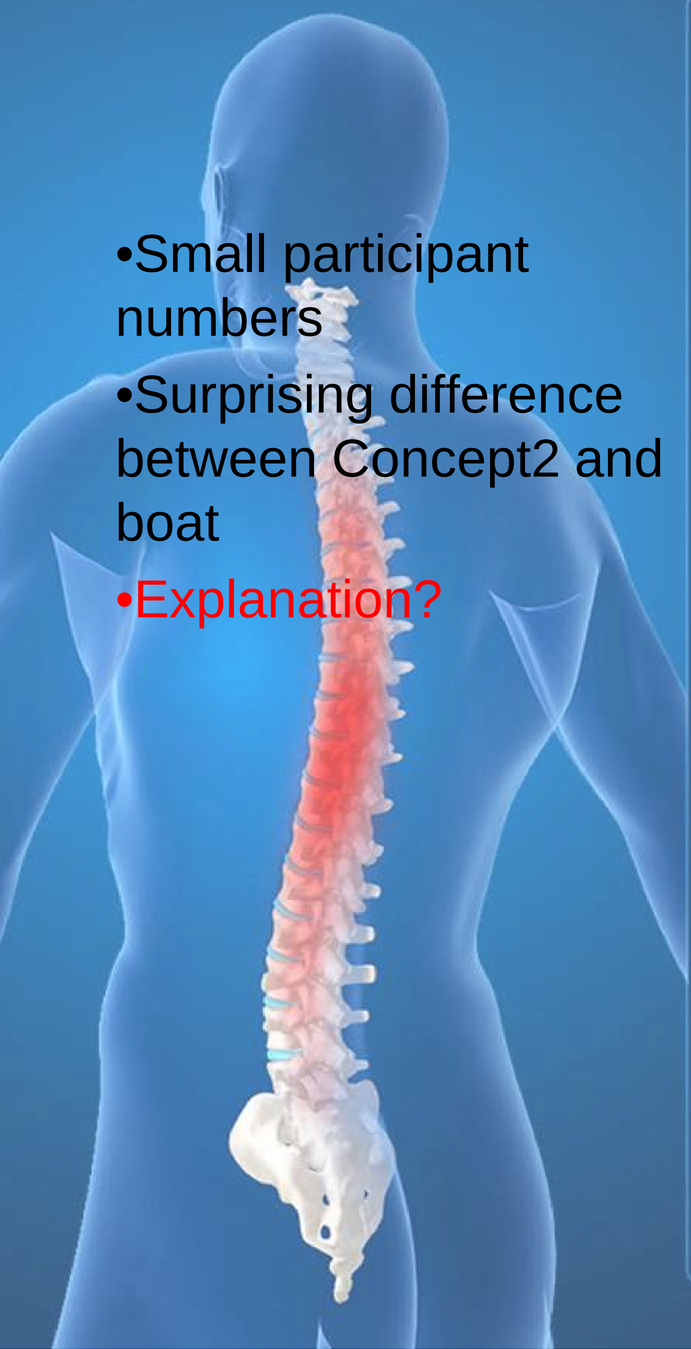
Time period	***R2***
0-180s	0.20
210-390s	0.020
420-600s	0.098
630-810s	0.183
840-1020s	0.215
1050-1230s	0.213
1260-1440s	0.002

Explained variation in frontal plane angular displacement at L3 from lactate scores during the step test.

- Frontal plane behaves like sagittal plane (previous data).
- Both frontal and sagittal plane reach high range of motion. Mean angular displacement varied from 4.6º (1st step) to 8.7º (last step).
- Implications for high ROM and injury.
- Motion increased during rowing test which may be due to fatigue and/or increasing stroke rate.
- High stroke rate combined with fatigue may increase risk of injury.

- Thus, a significant increase in frontal plane motion at L3 during incremental test.
- Increase in Bla was associated with the increased L3 motion, increase
- Increased stroke rate associated with increased L3 motion
- Thus, considerable motion in frontal plane during rowing and should be considered as a factor for injury
- Side flexion (frontal plane) combined with lumbar flexion (sagittal plane) with the addition of loading has been observed to be a risk factor for low back pain.

• Ergometer compared to water?



- Small participant numbers
- Surprising difference between Concept2 and boat
- Explanation?

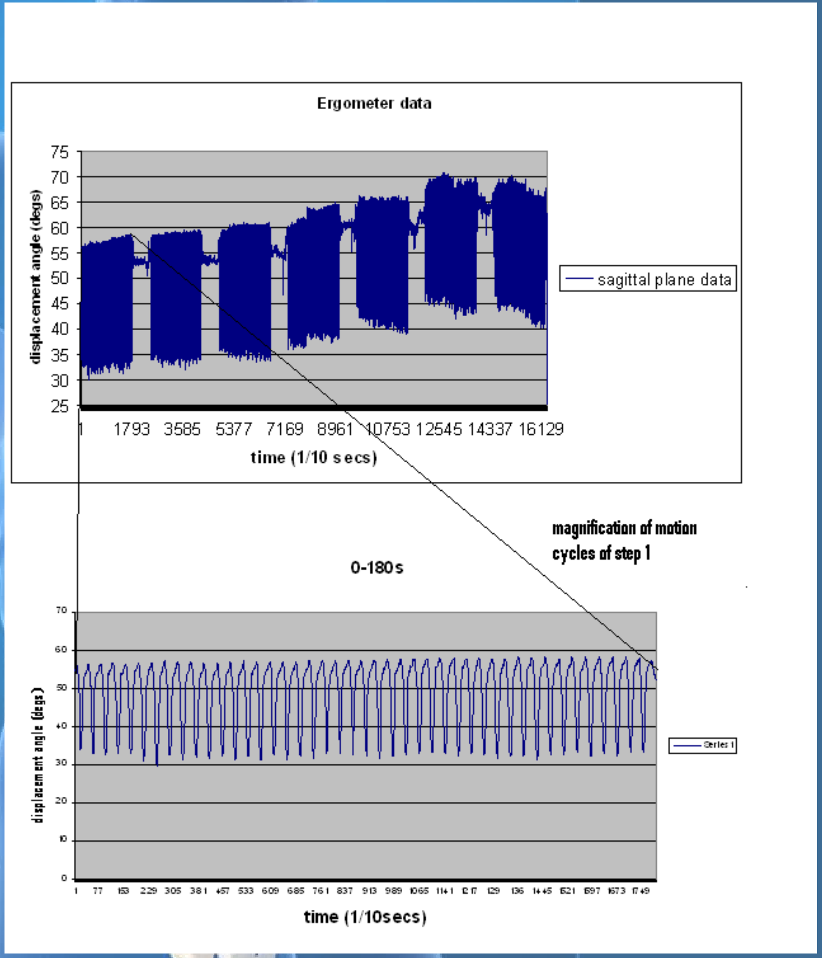
	100s boat	*100 s C2*	*300s boat*	*300s C2*	*500s boat*	*500s C2*
Subject	Average displacement (degrees)					
1	2.5	2.5	4.9	2.3	3.7	4.6
2	5.4	2.5	1.0	2.4	2.9	4.0
3	3.7	7.3	3.9	7.6	3.2	7.5
4	3.1	5.6	2.7	4.0	0.6	6.5
5	3.1	4.6	5.7	8.8	4.7	4.3
Mean	**3.6**	**4.5**	**3.6**	**5.0**	**3.0**	**5.4**
t-test		*P=0.45*		*P=0.28*		*P=0.12*

Table 3.3: Comparison of mean frontal angular displacement values for ergometer (C2) and boat rowing.

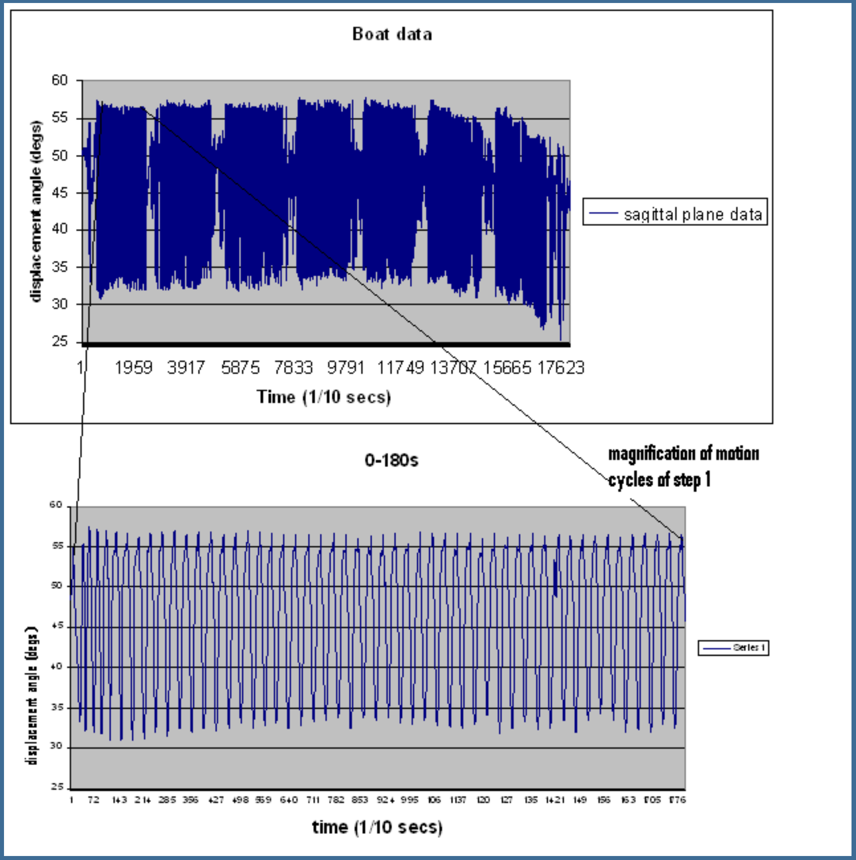
Sagittal plane – water compared to ergometer?

- LSp ROM (sagittal plane) measured using a flexible EGM Sample at10Hz)
- EGM placed over L2 - L4 (segment of greatest sagittal motion)
  - Full standing flexion was measured
  - Incremental step test
  - Heart rate recorded for each step then repeated in a sculling boat using recorded HR.

Results

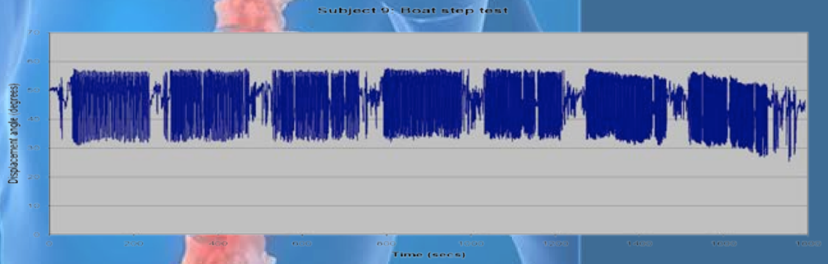


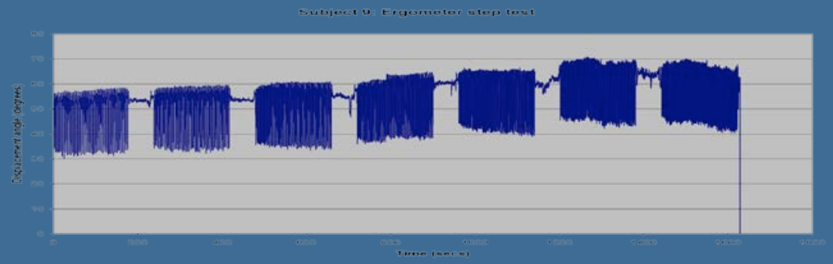
Ergometer data
displacement angle (degs)
75 70 65 60 55 50 45 40 35 30 25
1 1793 3585 5377 7169 8961 10753 12545 14337 16129
time (1/10 secs)
sagittal plane data
magnification of motion cycles of step 1
0-180s
70 60 50 40 30 20 10 0
displacement angle (degs)
Series 1
time (1/10secs)



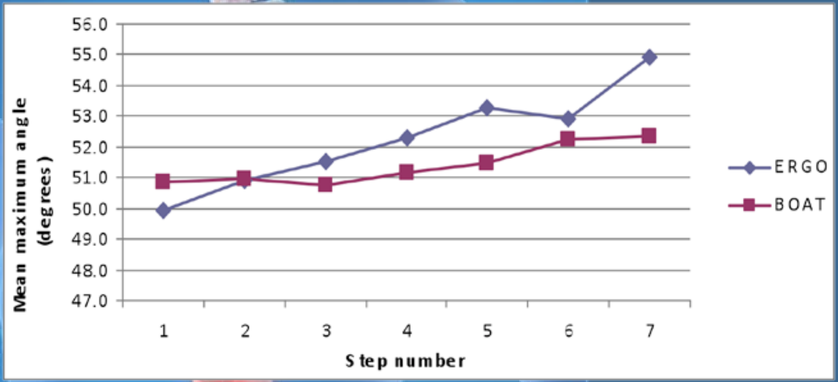
Boat data
displacement angle (degs)
60 55 50 45 40 35 30 25
1 1959 3917 5875 7833 9791 11749 13707 15665 17623
Time (1/10 secs)
sagittal plane data
0-180s
magnification of motion cycles of step 1
displacement angle (degs)
Series 1
time (1/10 secs)

Ergo versus boat





Summary



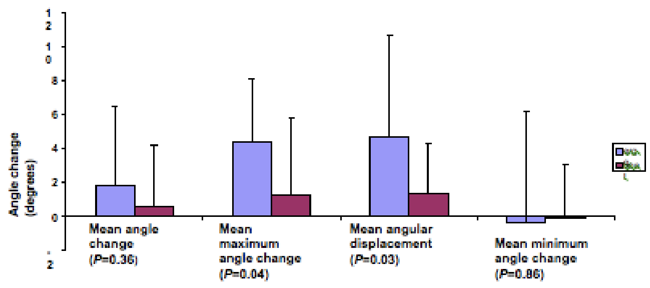


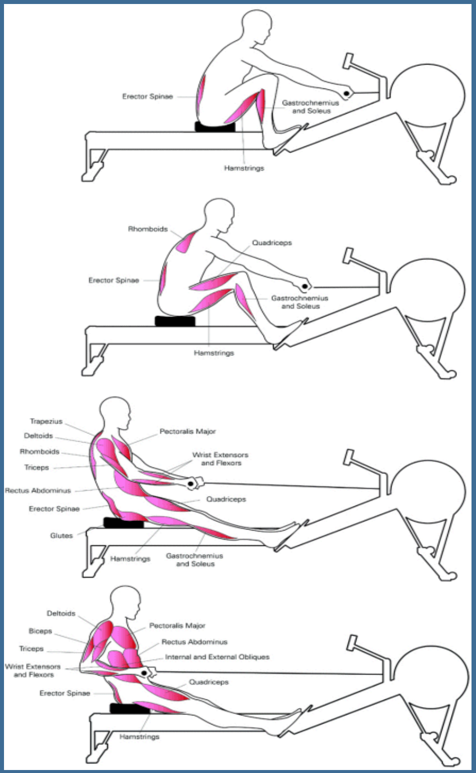
Figure 6.3: Chart to show the differences in mean lumbar spine sagittal angle between ergometer and boat rowing (with SD).

Explanation?

- Kleshnev (2003)[24] showed that the foot stretcher force develops much earlier on the ergometer as a result of higher inertia forces which the rower has to overcome to change direction of body mass movement, and the handle force on the ergometer has a higher peak and develops later.
- Kleshnev, (2005)[25] showed that rowers have a 3-5% longer stroke on an ergometer because of an 8-10% longer leg drive.
- Lamb, (1989)[26] showed that the leverage of pull on the oar is greater for ergometer rowing than for water rowing.
- Thus a greater increase in lumbar flexion is seen in ergometer rowing as a result of greater 'spinal creep'
- Repetitive cyclic flexion combined with loading of the lumbar spine, has been recognised in a number of studies to increase risk of lumbar spine injury[27-31]

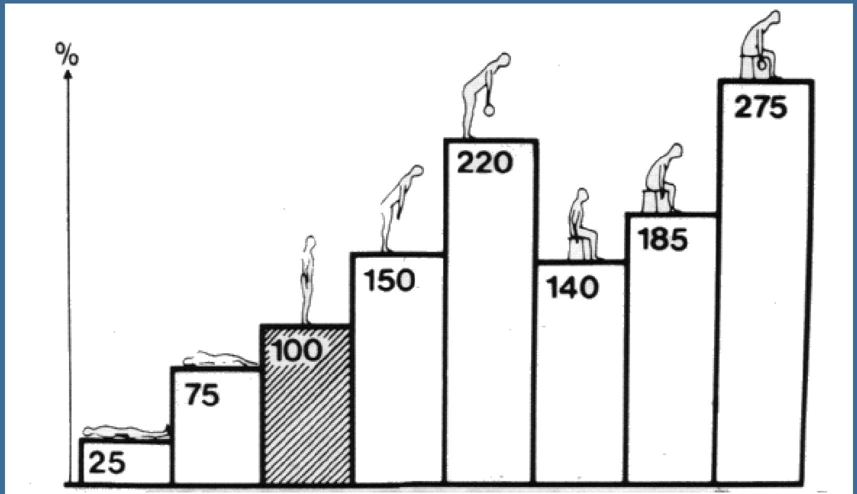
Muscle activity

- Emphasis on examining ergometer activity and on EMG activity rather than measures of strength and endurance
- No difference in overall trunk strength between rowers and controls, rowers exhibited higher EMG activity in their trunk extensors[32].
- Activity of the spinal extensor muscles was high and increased as 2000m ergo test continued[33] and spinal extensor muscle activity dominated the rowing stroke[34].
- Analysis of cross sectional area of muscles at 2 levels of the Lsp showed differences between groups of rowers who had no history or present/previous history of back pain[35].
- Asymmetry is common and may not be related to sweep rower's developed dominance[36]



Forces acting on the lumbar spine in rowing

- Compressive and shear force estimated at L4/5 (2D spinal model) during a 6 min (max) ergometer test.
- Peak compressive and shear forces calculated as 2730 (609) N and 693 (117) N respectively.
- Peak compressive force generated 28-29% of the way through the drive phase of the stroke.
- Peak compressive forces generated at the lumbar spine were 4.6 times the rowers' body weight[37].



In vivo (live person) loads on L3-4 disc. Standing=100
From: Nachemson, A. L.: The lumbar spine, an orthopaedic challenge. Spine 1:59, 1976

Summary & interpretation

- Lifting weights from the ground requires the LSp to be flexed by 70-80% of full standing flexion (toe touching) generating substantial tension in non-contractile tissues of the back'[38].
- Mean intradiscal pressure at (L4/5) of 2.30MPa when lifting a 20kg weight with a 'bent over round back' and a pressure of 0.83MPa when sitting with maximum lumbar flexion[39], horizontal intradiscal pressure in sitting at L4/5 as 1133kPa[40].
- Rowers achieve such high levels of sagittal flexion - then combined with loading which correlates with work place studies which have cited both of these factors as risk for low back injury[41] Individually, these factors increase injury risk, but when combined as in this case, risk is increased further.
- A number of studies have found that the combination of flexion and 'twisting', combined with loading was a specific risk factor for onset of low back pain[41-43]
- Repeated cyclical loading has been noted as a risk factor for lumbar spine injury in a number of previous studies[41-45]
- Cyclical loading induces 'creep' in the tissues allowing an increase in initial range of motion and may increase risk of injury in a number of ways[46]
- Creep induced in the viscoelastic tissues of the spine desensitises the mechanoreceptors causing decreased muscle activity, instability and injury even before muscle fatigue of sets in'.
- Reflexive muscular stabilising forces in the lumbar muscles are compromised increasing risk of injury.

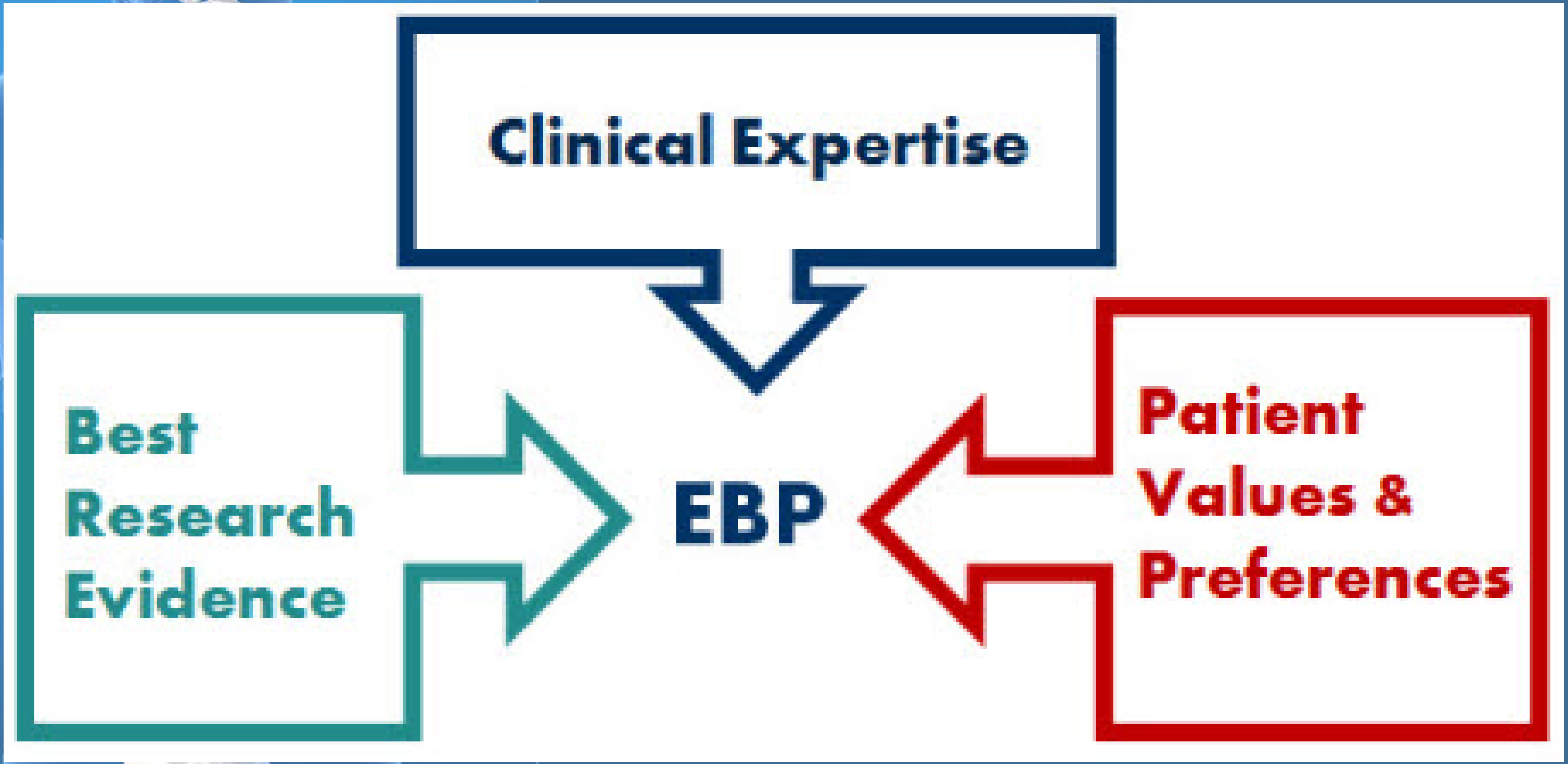
The Phenomenon of 'creep'

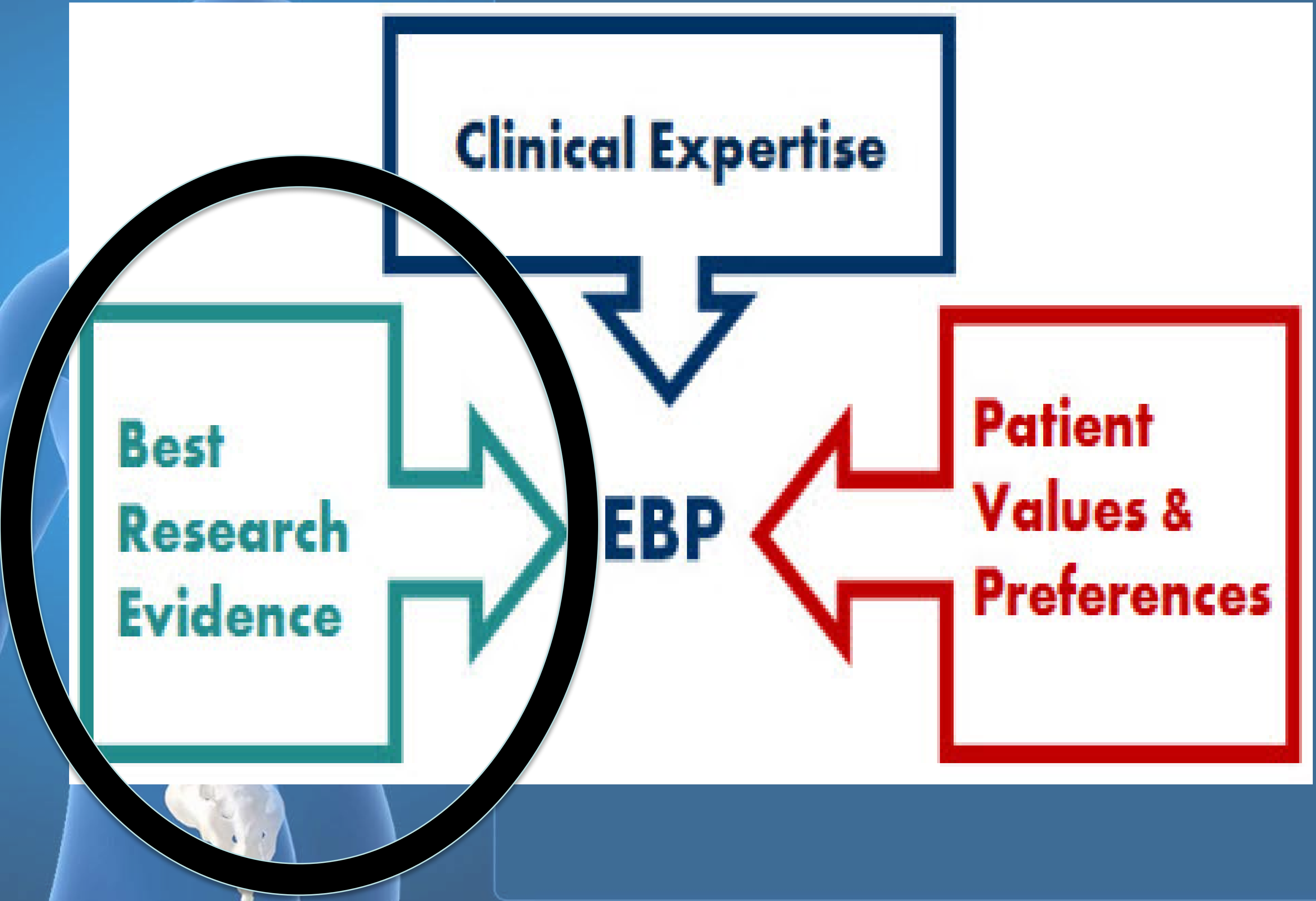
- Fatigue in the lumbar extensor muscles allows the increase in lumbar flexion with an associated increased bending moment which increases injury risk[47,48]
- Sanchez-Zuriaga et al.,[49] suggests that tissue creep rather than muscle fatigue impairs sensorimotor control mechanisms.
- Repeated loaded cyclical flexion compromises neuromuscular control (leading to increased injury risk) has been confirmed in a number of studies[49-51]
- Creep behaviour further cause specific damage to lumbar tissues, most notably intervertebral disc[52,53] but also vertebral bodies and endplates[54] and facet joint capsule[55]
- Prolonged cyclical loading of the lumbar spine in flexion/extension not only elicits creep but also causes significant increases in cytokines expression, causing acute inflammation for several hours after the activity[51,56]
- If the inflamed lumbar spine is continued to be exposed to repetitive loading on a daily basis this may lead to 'conversion to chronic inflammation, degeneration of the viscoelastic tissues into fibrous non-functional tissue and the associated mechanical and neuromuscular disorders and loss of function'[56].
- Elite rowers frequently row on a daily basis which means that the loading described above is indeed regular and sustained; this may help to explain the high incidence of lumbar spine injury in this group.

Specificity of tissue damage

- Annulus and nucleus work together to sustain compressive loads[38] - increased compressive load on the neural arch is caused by long term ‘creep’ loading
- High anterior disc compressive force is noted in high ranges of flexion[57]
- Repeated cyclical loading and high levels of spinal flexion exhibited by rowers have been shown to cause lumbar disc bulging[58] herniation[53] and facet joint capsule strain[59]
- Compression forces noted in the rowers LSp - comparable to those seen during lifting which can cause fractures of the vertebral endplates[60]
- Lumbar ligaments - primary role to resist separation at end range. Thus likely that high tensile forces and resulting tissue damage are observed in the ligaments that resist frontal and sagittal motion in the LSp in rowers.
- Facet capsules, posterior longitudinal ligaments and posterior annulus contribute more than 3/4 of resistance to lumbar flexion. Micro damage and associated inflammation in the spinal ligaments may become chronic[61].
- Due to impairment of sensorimotor control mechanisms - reflexive activation of multifidi and longissimus muscles is decreased during repetitive motion - likely that rowers suffer associated reduction in muscular protection of the underlying spine.
- Rowers are at risk of sustaining damage to a variety of structures of the lumbar spine, notably the disc, ligaments and facet joint capsule as well as impairment in muscle function.

Translating evidence into practice




Clinical Expertise
Best Research Evidence
EBP
Patient Values & Preferences

Injury prevention
Ergometer

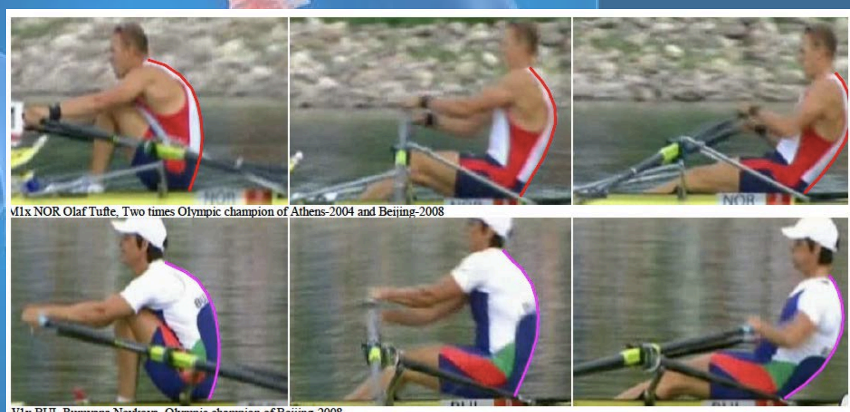
- The length of the ergometer session should be reduced as risk of lumbar spine injury increases with the number of loading cycles
- Ergometer should never be used as a warm-up, particularly for weight training
- Ergometer technique should be examined (elite vs. novice – appropriate goals)
- Damper settings
- Consider use of non-fixed ergometers
- Foot stretcher position – higher foot stretcher, dec L5/S1 moments but inc L5/S1 shear

Injury prevention
Posture and kinematics

Rob Bristow (http://www.total.rowing.org.uk/voice/voice5-1.pdf):

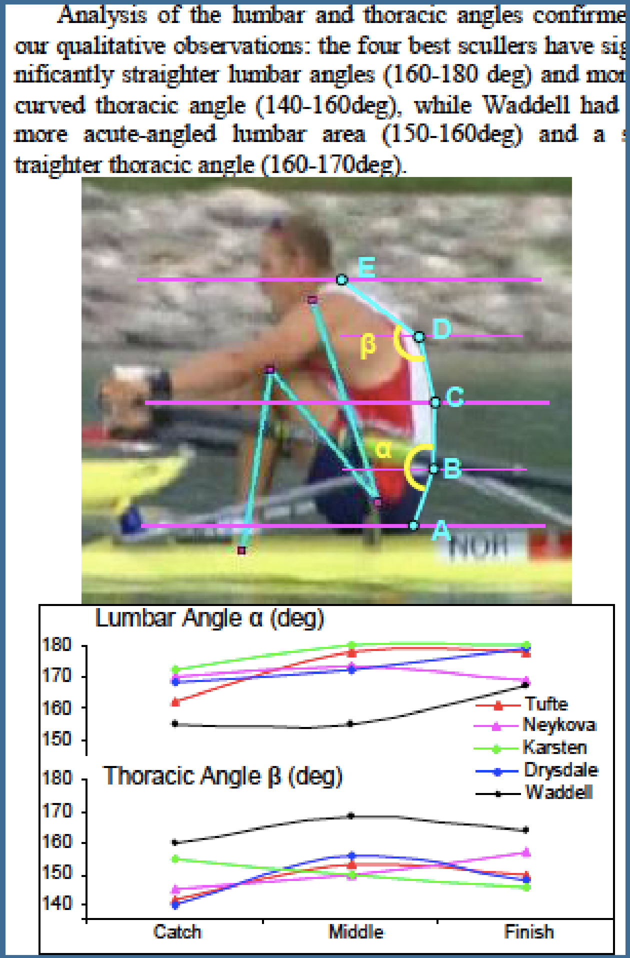
We can see how different the contours of the back in these two great scullers (Rob Waddell in the foreground and Mahe Drysdale in the background). When we draw the contour lines, scale and overlap them, the difference is obvious: Mahe has a straighter lower back and more curvature in the chest, where as Rob has the opposite.

Injury prevention
Posture and kinematics



Injury prevention
Posture and kinematics

- A straighter lumbar spine helps to better transfer force from hips to shoulders and prevents injury
- More curvature in the thoracic spine can be more economical because it uses elastic properties of the muscles rather than strength


Analysis of the lumbar and thoracic angles confirme our qualitative observations: the four best scullers have sig nificantly straighter lumbar angles (160-180 deg) and mor curved thoracic angle (140-160deg), while Waddell had more acute-angled lumbar area (150-160deg) and a s traighter thoracic angle (160-170deg).

Injury prevention
Posture and kinematics
…. The 'c' curve or the 'f' curve?

- Swing from hips
- Vertical shins
- Keep head moving *horizontally*
- Flex through full spine, 'unroll' vertebrae evenly

The ‘C’ Spine?

- Prof Richard Aspden: curvature of the spine is necessary for its load-bearing function
- Spine considered as an arch with load distributed evenly through segments
- Arch collapses if a hinge forms as it turns the structure into a ‘mechanism’
- Collapse can be prevented by tensile strength of tissues but formation of hinges may lead to tissue damage
- Thrust line must be within equilibrium and lies within cross section of arch

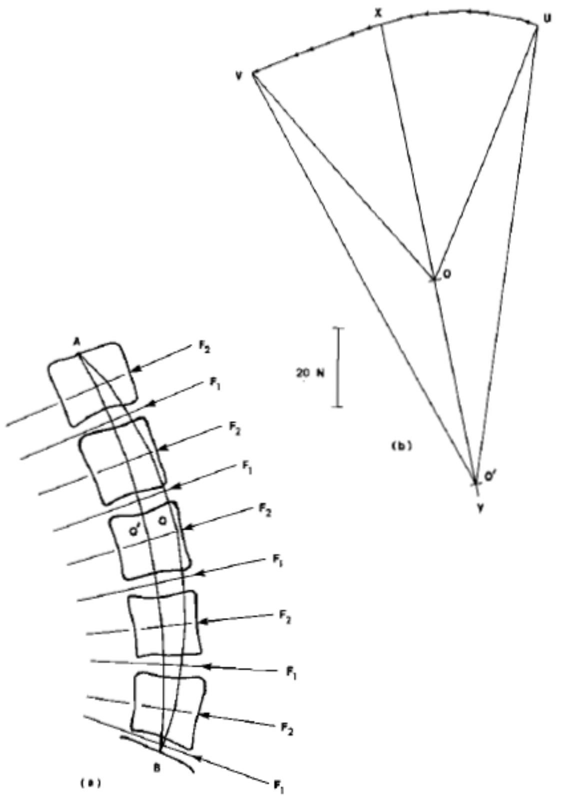


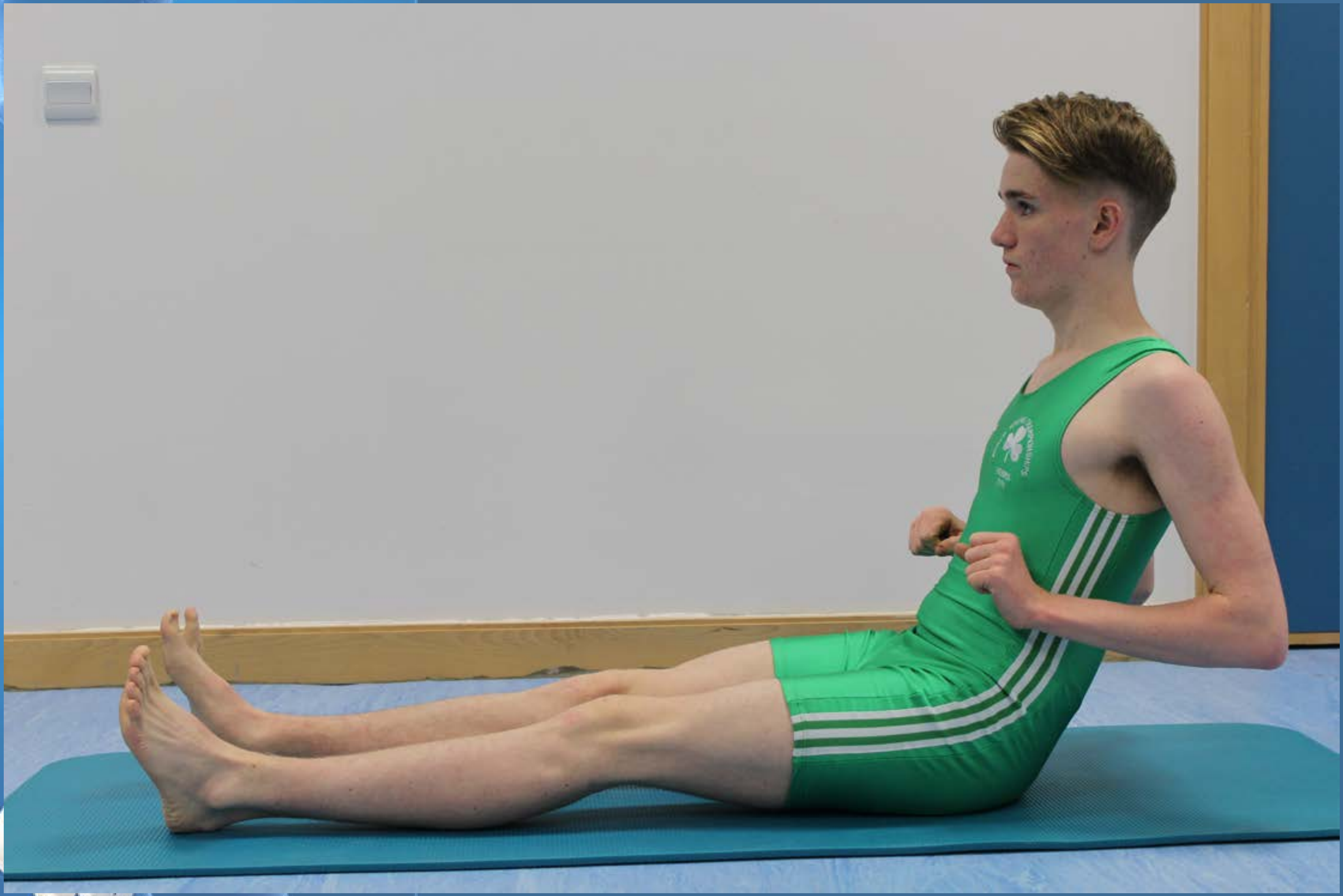
Fig 5. The lumbar spine in the normal erect posture, **a**, A and B lie on the center line of the arch formed by the vertebrae. AOB and AO′B are thrust lines calculated from the force polygon, **b**, and correspond to positions of the pole O and O′ respectively. Only the first and last rays have been drawn from O and O′ in b.

Importance of intra-abdominal pressure

- Valsalva manoevre adopted as a reflex to increases intradiscal pressure, protects spine and may prevent hinging or buckling
- Varies widely between individuals

Injury prevention
Screening


Screening



Screening

Rehabilitation

- Modern rehabilitation of low back pain has placed particular emphasis on co – contraction of the trunk muscles, particularly using protocols such as Pilates type exercise.

- The findings of research suggest that during peak force generation, such co– contraction does not exist and the extensor muscles dominate.

- Rowers may be using inappropriate rehabilitation protocols.

- Traditional ‘core stability’ programmes, with their emphasis on co-contraction are included in most rowers’ training

- Research suggests that more emphasis should be placed on training the spinal extensors as well as training eccentric action of the flexors.

Rehabilitation
Range of motion/flexibility

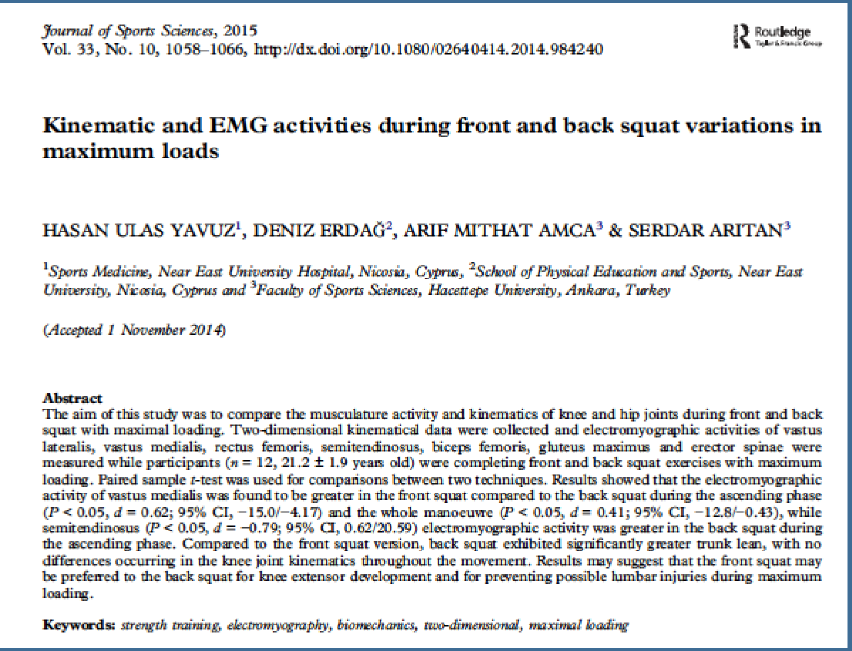
- Emphasis on hip range – particularly bilateral
- Ability to dissociate hip from lumbar motion
- Hip/knee ankle complex
- Asymmetries important?

Rehabilitation
Range of motion/flexibility

- Spinal motion
- Emphasis on thoracic kyphosis
- Very individual
- Consider response to fatigue
- Underlying systemic disorder?

Rehabilitation
Muscle strength/endurance

- Emphasis on both eccentric and concentric contraction of trunk extensors
- Front versus rear squat?
- Emphasis on DYNAMIC activity rather than isometric
- AVOID PLANKS!



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Kinematic and EMG activities during front and back squat variations in maximum loads

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(*Accepted 1 November 2014*)

Abstract
The aim of this study was to compare the musculature activity and kinematics of knee and hip joints during front and back squat with maximal loading. Two-dimensional kinematical data were collected and electromyographic activities of vastus lateralis, vastus medialis, rectus femoris, semitendinosus, biceps femoris, gluteus maximus and erector spinae were measured while participants (n = 12, 21.2 ± 1.9 years old) were completing front and back squat exercises with maximum loading. Paired sample t-test was used for comparisons between two techniques. Results showed that the electromyographic activity of vastus medialis was found to be greater in the front squat compared to the back squat during the ascending phase ($P < 0.05$, $d = 0.62$; 95% CI, −15.0/−4.17) and the whole manoeuvre ($P < 0.05$, $d = 0.41$; 95% CI, −12.8/−0.43), while semitendinosus ($P < 0.05$, $d = -0.79$; 95% CI, 0.62/20.59) electromyographic activity was greater in the back squat during the ascending phase. Compared to the front squat version, back squat exhibited significantly greater trunk lean, with no differences occurring in the knee joint kinematics throughout the movement. Results may suggest that the front squat may be preferred to the back squat for knee extensor development and for preventing possible lumbar injuries during maximum loading.

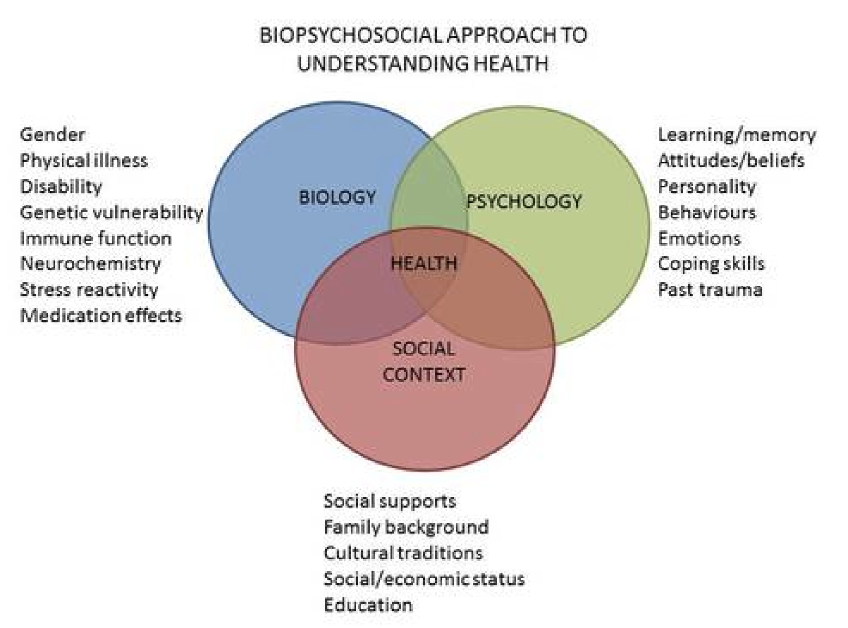
Keywords: *strength training, electromyography, biomechanics, two-dimensional, maximal loading*

Rehabilitation
Proprioception

- Position sense is compromised following injury
- Ergometer studies also suggest that fatigue may compromise (ergo vs. water studies)

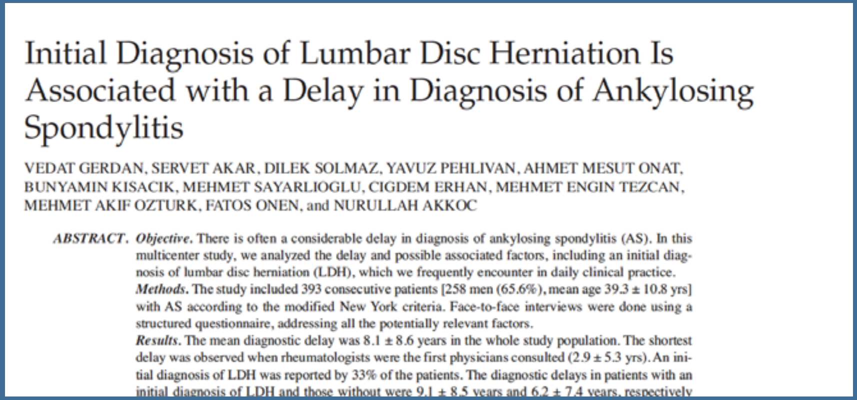
….. What about biopsychosocial approaches?

- Fear avoidance
- Catastrophising
- Hypervigilence
- Strong evidence that understanding cognitive components of LBP is key to management
- Likely to be no different in rowing
- Recent studies incorporate CBT



…. A word of caution – red flags

- Always consider inflammatory disorder
- Rheumatoid disorders much more prevalent in population than previously thought
- Exercise so important in AS, RA (etc) management that presentation becomes sub clinical
- And of course, other red flags. Tired rowers= poor historians!



Initial Diagnosis of Lumbar Disc Herniation Is Associated with a Delay in Diagnosis of Ankylosing Spondylitis

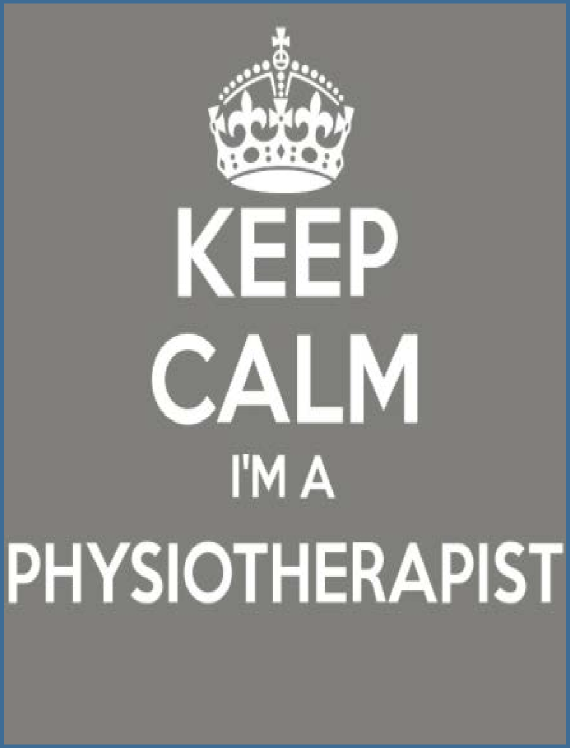
VEDAT GERDAN, SERVET AKAR, DILEK SOLMAZ, YAVUZ PEHLIVAN, AHMET MESUT ONAT, BUNYAMIN KISACIK, MEHMET SAYARLIOGLU, CIGDEM ERHAN, MEHMET ENGIN TEZCAN, MEHMET AKIF OZTURK, FATOS ONEN, and NURULLAH AKKOC

ABSTRACT. ***Objective.*** There is often a considerable delay in diagnosis of ankylosing spondylitis (AS). In this multicenter study, we analyzed the delay and possible associated factors, including an initial diagnosis of lumbar disc herniation (LDH), which we frequently encounter in daily clinical practice.
Methods. The study included 393 consecutive patients [258 men (65.6%), mean age 39.3 ± 10.8 yrs] with AS according to the modified New York criteria. Face-to-face interviews were done using a structured questionnaire, addressing all the potentially relevant factors.
Results. The mean diagnostic delay was 8.1 ± 8.6 years in the whole study population. The shortest delay was observed when rheumatologists were the first physicians consulted (2.9 ± 5.3 yrs). An initial diagnosis of LDH was reported by 33% of the patients. The diagnostic delays in patients with an initial diagnosis of LDH and those without were 9.1 ± 8.5 years and 6.2 ± 7.4 years, respectively

Translating evidence into practice

What do the clinicians say?

- Risk factors
- Screening
- Early Management
- Prognostic indicators
- Rehabilitation



Risk factors

- Hip joint ROM – influences spino-pelvic kinematics
- Labral, CAM lesions, FAI
- General hypo or hypermobility
- Dysfunctional movement patterns
- Males – poor hip flexion
- Females – poor trunk strength or hypermobility
- Weather (wind)
- Time of season
- Sudden increased training load
- Technical problems (boat off balance, rigging)
- Recovery period between water and gym
- Previous injury
- Delayed recognition
- Mixed messages from support staff

Screening

- Hips – weight bearing and position on ergometer
- Weight bearing ankle dorsiflexion
- Lateral hip stability and gluts
- Hip arthroscopy – early degenerative changes
- Lumbopelvic rhythm – consider as a complex
- Perturbation strategies
- Compensation in systems
- Movement patterning
- Questionnaire screening tools (e.g.. Keel STaRT Back screening tool)
- Newlands – no correlation of screening with risk

Early management

- Analgesia, NSAID's where appropriate
- Investigations?
- * Do no harm – training attenuation
- Normal movement
- Proprioceptive taping
- Isometrics

- Emphasis on non-generic, individual Rx
- Assess for red/yellow flags
- Reassure that not normal to have pain
- Education/mindfulness/cognitive input
- Determine mechanical/cognitive/structural emphasis

Management – investigations?

Table 6. Imaging Findings [No. (%)] *Versus* Age Group

Imaging Finding	Age Group: <45 yr (n = 31)	45–55 yr (n = 53)	55–65 yr (n = 35)	5 yr (n = 29)	t Statistic*	2-sided P	Adjusted OR† (95% CI)
Disc degeneration	24 (77)	49 (93)	32 (91)	29 (100)	−3.35	<0.01	1.13 (1.04, 1.23)
Desiccation (moderate or severe)	20 (65)	42 (79)	32 (91)	29 (100)	−4.14	<0.01	1.12 (1.05, 1.20)
Loss of disc height	13 (42)	27 (51)	23 (66)	20 (69)	−2.56	0.01	1.06 (1.02, 1.10)
Bulge	14 (45)	34 (64)	23 (66)	24 (83)	−3.55	<0.01	1.08 (1.03, 1.13)
Protrusion	9 (29)	18 (34)	11 (31)	10 (35)	−0.01	0.99	1.01 (0.97, 1.05)
Extrusion	0 (0)	6 (11)	2 (6)	1 (3)	0.34	0.73	1.01 (0.92, 1.10)
Nerve root compromise	0 (0)	2 (4)	1 (3)	2 (7)	−0.90	0.37	1.08 (0.96, 1.21)
Annular tear	12 (39)	19 (36)	13 (37)	12 (41)	0.14	0.89	0.99 (0.96, 1.03)
Endplate changes	1 (3)	9 (17)	15 (43)	14 (48)	−5.00	<0.01	1.13 (1.07, 1.19)
Stenosis (moderate or severe)	2 (7)	3 (6)	4 (11)	6 (21)	−2.07	0.04	1.09 (1.02, 1.16)
Facet joint degeneration (moderate or severe)	0 (0)	4 (8)	12 (34)	11 (38)	−4.39	<0.01	1.14 (1.07, 1.21)
Spondylolisthesis	2 (6)	5 (9)	9 (26)	10 (35)	−3.33	<0.01	1.09 (1.03, 1.15)

* Independent samples t test.
† Adjusted odds ratio from logistic regression analysis: $y = \alpha + \beta_1 Age + \beta_2 Gender$ … ace $+ \beta_4 Smoking + \beta_5 Height + \beta_6 Weight + \beta_7 BMI + \beta_8 Past\ pain$, where y = imaging finding and $\exp(\beta_1)$ = adjusted odds ratio.

Table 4. Prevalence [no. (%)] of Imaging Findings by Lumbar Spine Level

Imaging Finding	Lumbar Spine Level: L1–L2	L2–L3	L3–L4	L4–L5	L5–S1	Overall*: All†	Pristine‡
Disc degeneration	55 (37)	62 (42)	81 (55)	99 (67)	108 (73)	134 (91)	98 (92)
Desiccation (moderate or severe)	44 (30)	58 (39)	69 (47)	78 (53)	95 (64)	123 (83)	91 (86)
Loss of disc height	21 (14)	14 (10)	20 (14)	41 (28)	44 (30)	83 (56)	60 (57)
Bulge	26 (18)	26 (18)	48 (32)	70 (47)	54 (37)	95 (64)	69 (65)
Protrusion	3 (2)	9 (6)	12 (8)	18 (12)	29 (20)	48 (32)	37 (35)
Extrusion	0 (0)	0 (0)	1 (1)	4 (3)	5 (3)	9 (6)	5 (5)
Nerve root compromise	0 (0)	0 (0)	0 (0)	1 (1)	4 (3)	5 (3)	3 (3)
Annular tear	4 (3)	7 (5)	15 (10)	26 (18)	30 (20)	56 (38)	45 (42)
Endplate changes	6 (4)	8 (6)	10 (7)	14 (10)	19 (13)	39 (26)	24 (23)
Stenosis (moderate or severe)	0 (0)	4 (3)	4 (3)	6 (4)	4 (3)	15 (10)§	7 (7)§
Facet degeneration (moderate or severe)	0 (0)	3 (2)	4 (3)	16 (11)	9 (6)	27 (18)	19 (18)

* Present at one or more levels.
† All subjects in cohort.
‡ Those subjects with modified Roland = 0; pain frequency score = 4; pain bothersomeness score = 4 (n = 106).
§ χ^2 test: $P < 0.05$.

Consider for historical comparator from baseline
Rapid diagnosis
Radiculopathy

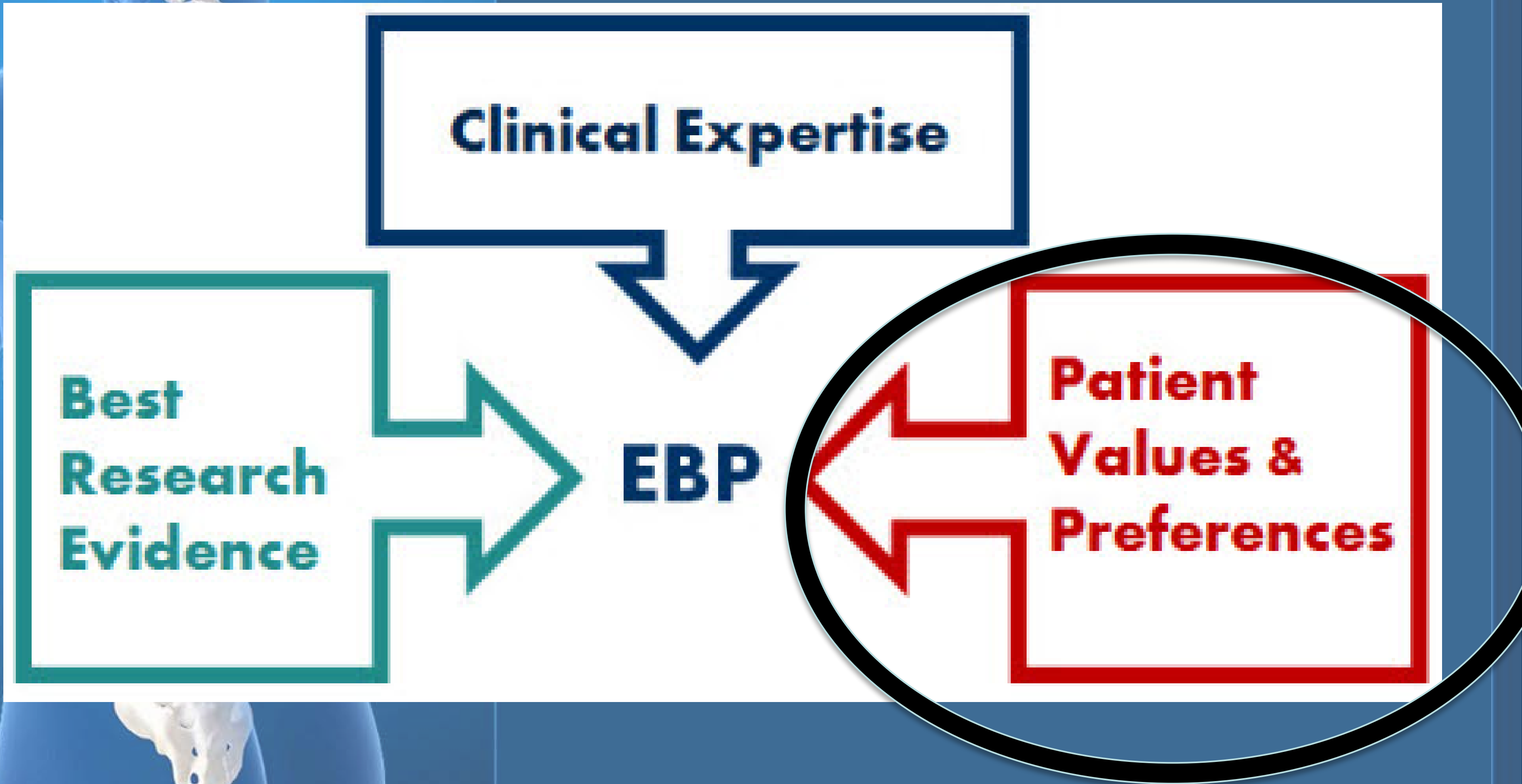
Prognostic indicators

- Previous history may indicate course
- Catastrophic onset associated with poorer prognosis
- Radicular pain – poorer prognosis
- Inflammatory component
- Fixed structural deficit in kinetic chain (e.g. congenital limitation of hip ROM)
- See risk factors

Rehabilitation

- Early control of motion segment/ address movement faults
- Attention to lumbo-sacral junction and load
- ROM ex to improve positioning
- Trunk endurance to emphasize extensors
- Early return to rowing – avoid ergometer
- High reps in S&C – consider effects of fatigue on proprioceptive function
- Feedback tools
- Consider athlete as a whole system and consider interaction of kinetics
- Consider implications of small changes on whole athlete
- Consider compensations in systems
- Specificity in rehab, especially core. Reformer Pilates and dynamic activities most appropriate

What's missing?



In summary

- Factors associated with onset of LBP in rowers are history of previous injury and ergometer training volume.

- Lumbopelvic motion should be considered when analyzing trunk movement in rowing. Excessive use of lumbar flexion and extension without accompanying pelvic tilting may lead to increased lumbar spine loading.

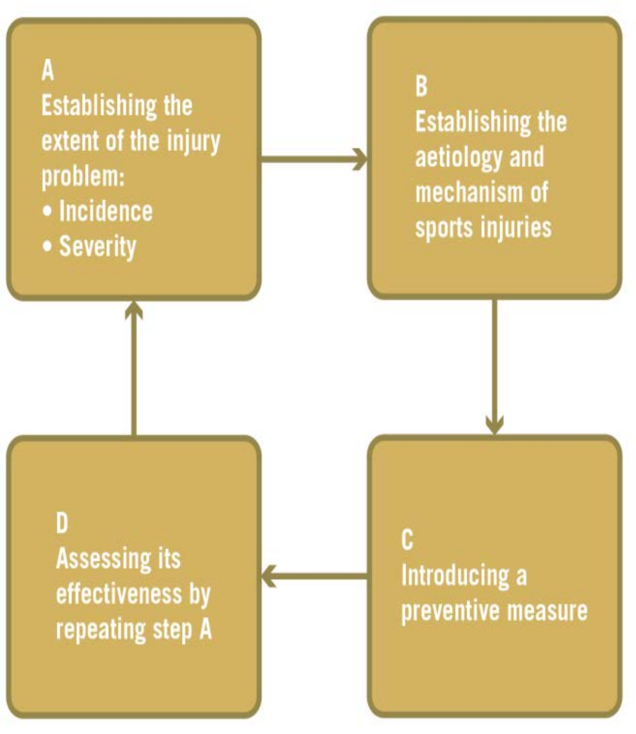
- Rowing training and rehabilitation needs to consider endurance of the trunk muscles to facilitate good lumbopelvic rhythm. Factors such as fatigue, rowing intensity and skill level will also influence trunk control.

- Hip ROM and lower kinetic chain flexibility will influence lumbar loading

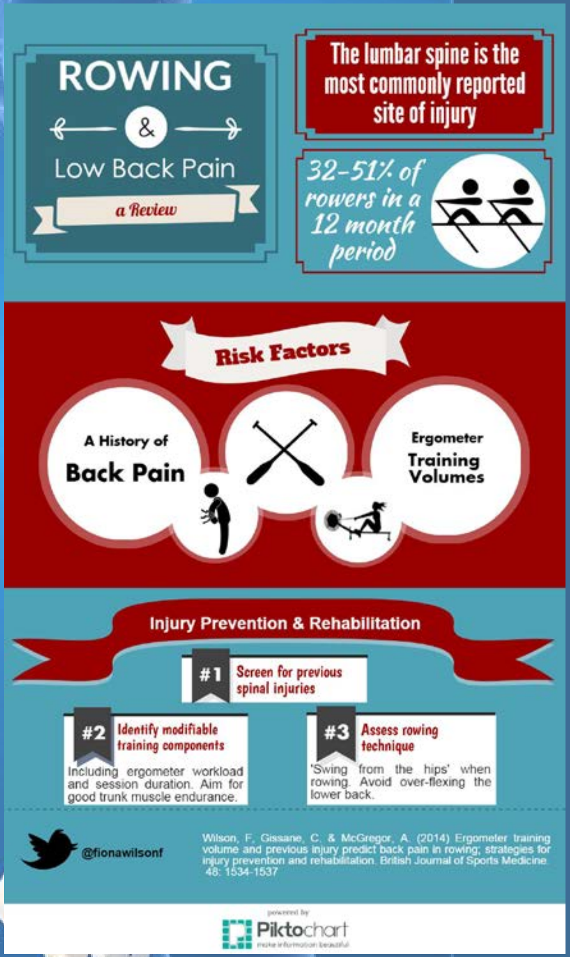
- A non-generic approach is optimal with a consideration of the complexities of LBP presentation

The future

- Multi-centre prospective injury study at multiple levels of rowing
- Real time feedback tools
- Consensus statement on low back pain management
- Trials examining management interventions
- Back pain screening tool designed for rowers
- Greater efforts to disseminate research findings and clinical expertise



Thank you – questions?



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