Isokinetic Trunk Testing and Training for Hong Kong Rowers - a Prophylactic Treatment for Low Back Pain

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Title : **Isokinetic trunk testing and training for Hong Kong Rowers - a prophylactic treatment for low back pain.**

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Abstract :

Low back pain is the most frequent complaints among rowers in the Hong Kong National Squad despite vigorous physical conditioning. 17% of the training sessions was stopped or altered due to low back pain during the study. This condition can be very disabilitating and annoying.

The purpose of this study is to :

1. Identify the correlation of low back pain, training pattern, years of experience in rowing and stroke style.

2. Assess the effect of isokinetic trunk flexion / extension exercise on muscle strength, power and endurance.

3. Evaluate the effect of isokinetic trunk flexion / extension exercise on pain level and frequency.

4. To evaluate the duration of efficacy of the isokinetic trunk flexion / extension training programme.

14 rowers from the national squad were randomly divided into a training group and a control group. Everyone was asked to fill in a questionnaire weekly concerning their low back pain level and training pattern during the whole period of the study. Pain level was measured with a visual analog scale. The training group underwent an isokinetic trunk flexion / extension programme with Cybex TEF for 8 weeks. Trunk flexion /

extension testing before, immediately after and 8 weeks after the training programme was also carried out with the same equipment.

Results indicated that low back pain & frequency was positively correlated with training load and negatively correlated with years of rowing experience. Rowers were found to have higher incidence of low back pain than scullers. The isokinetic trunk flexion / extension exercise training programme was found to be effective in improving trunk muscle strength, power and endurance. Above all, it also helped to reduce the subjects' low back pain level and frequency. The efficacy lasted for at least 8 weeks after training. Perhaps such kind of programme should be incorporated into the rowers' training routine especially for those with less rowing experience who were proven to be more susceptible in getting low back pain. If the incidence of low back pain could be reduced or prevented, the rowers' performance and achievement will certainly be improved.

Rowing is a sport that requires technical skills, motor co-ordination, adequate strength and considerable endurance. [6,19,42] Rowers are very dedicated athletes, both in intensity of personal training and more especially in the development of team perfection. [11] High intensity routine training is usually carried out 3 times per day, 6.5 times a week all year round. In-season training regimen includes a mixture of long continuous exercise bouts at 75 to 85% of maximal work capacity and shorter interval training sessions at very high intensities up to 90-95% of maximum effort. [18] This kind of high pressure training schedules and the biomechanical demand of the rowing stroke lead to different injuries. [11,22,34,40,42,43,47,49,54,55,57] The most frequent complaint is low back pain.

At the Australian Institute of Sport, 73% of the rowers from the rowing squad presented to the Sports Medicine Unit with low back symptoms in 1986-1987. [58] One American study found that 82% of elite rowers had back pain problems and they were all less than 30 years old. [47] Another survey carried out in the USA revealed a 44% prevalence of chronic back pain in rowers. [19] In the year 1995-1996, 90% of the rowers from the Hong Kong national squad had attended the physiotherapy clinic in the Sports Medicine Department of the Hong Kong Sports Institute for the treatment of low back pain. Some got better in a few days while others took months to recover. This condition can be very disabilitating and annoying. The athletes' psychological and physical status are both affected.

Torsional and compression forces are the most likely factors causing many of the rowing back injuries. In the lumbar spine, torsional forces may lead to annulus disc tears and injuries of the facet joints. [34] Previous torsional injuries of the annulus fibrous may also predispose to nuclear herniation. [8] Compression forces may result in herniation of the nucleus pulposus into the spinal canal. [12] As Boland and Hosen[6] stated, the average peak compression loads during rowing are as high as 5000N to 6000N in female and male respectively, approximately 7 times the body weight during the

drive phase. The constant repetitive forward flexion and rotational stresses in rowing are a natural set up for irritation of the joints, soft tissues and particularly the discs. The problem is aggravated when there is muscle fatigue and the control of movement becomes slack. Failure to stabilise the pelvis and spine during the drive phase may produce abnormal forces that result in low back injuries. [41]

Medical evidence suggests that more than 80% of all low back pain cases are caused by weak trunk muscles. [16] It might not be too appropriate if we apply this to rowers who have high level of physical conditioning. Nevertheless, strong muscles do enhance the spine's ability to withstand external loads. It is generally accepted that exercise is an effective preventive measure as well as treatment for low back pain. [2,7,10,15,16,44,51,52,53,58] Symptomatic relief is evident as muscle hypertrophy and power increase. [15]

The use of isokinetic exercise was prescribed for the treatment and rehabilitation of back patients [2,7,10,51,52] and had been proven to be effective. However, there is no available literature concerning the effect of isokinetic exercise for the prevention of low back pain in rowers. Isokinetic exercise is a good form of training from a physiotherapeutic point of view. It provides muscle training throughout the range of motion of a joint at a constant velocity of contraction while automatically accommodating the resistance to the developed muscle tension. [44] It is relatively "safe" since the resistance is never greater than the produced muscular tension. Besides, reciprocal exercise patterns (i.e. flexion / extension) can be performed. [44]

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3. Evaluate the effect of isokinetic trunk flexion / extension exercise on pain level and frequency.

4. To evaluate the duration of efficacy of the isokinetic trunk flexion / extension training programme.

Prevention is better than cure. If something can be done before low back pain actually occurs, training will no doubt become more effective and the athlete can also excel themselves to their best ability.

Method :

1. Subjects

There were 14 sweep rowers and scullers in the Hong Kong national squad when the study started. Most of them were training 3 times a day, 6.5 days a week. Their normal training included : on-water, ergometer and weight training. Descriptive profile of the subjects is shown in table 1. 13 out of 14 rowers attended the physiotherapy clinic of the Sports Medicine Department in the Hong Kong Sports Institute for the treatment of low back pain in the one year before the study began.

Table 1: Descriptive profile of the subjects

characteristic		No. of Athletes
Sex	Male	9
	Female	5
Age	15-20	2
	21-25	6
	26-30	2
	over 30	4
Rowing experience	over 5 years	4
	3-4 years	3
	1-2 years	4
	less than 1 year	3
Sweep rowing		8
Sculling		6

2. Procedures

Firstly, a questionnaire and record system was developed (Appendix 1 & 2) It consisted of three parts : (1) personal data (2) training record and (3) low back pain condition.

Pain level was measured with a visual analog scale. It was a 12 cm line with anchor words "no pain" at one end and "excruciating pain" at the other. Subjects were asked to rate their intensity of pain over the past week. This provided us information regarding their training pattern, low back pain level and frequency before, during and after the isokinetic training programme.

Subjects were randomly divided into two groups : (1) control group, & (2) training group. Sweep rowers and scullers from the control group carried on with their normal training. The training group underwent an isokinetic trunk flexion / extension exercise programme on the Cybex TEF (Cybex division of Lumex, Inc., NX 11779) for 8 weeks on a three times a week basis. The exercise consisted of 10, 12 and 16 repetitions of spinal flexion / extension at the speeds of 60°/sec, 90°/sec, 120°/sec respectively through a -15° to 60° range of spinal motion. Each bout was arranged in a velocity spectrum with the sequence entailing progressive stages from 60°/sec up to 120°/sec and then regressive stages back down to 60°/sec. 30 seconds rest was allowed between different speeds. Two bouts were performed every session.

All subjects were tested isokinetically before, immediately after and 8 weeks after the isokinetic trunk flexion / extension exercise programme with three test speeds : 60°/sec (5 repetitions), 90°/sec (5 repetitions) and 120°/sec (15 repetitions). The parameters used including : peak torque, average power, torque acceleration energy, total work, endurance ratio and flexion / extension ratio.

3. Data Analysis

Data were analysed using the statistical package for the social sciences (SPSS Inc, 444N Michigan Ave., Chicago, IL60611).

Simple factorial ANOVA was used to test for differences in isokinetic parameters between control and training group before and after the isokinetic trunk flexion / extension exercise programme. To determine associations of low back pain level and training pattern, Pearson product-moment correlation coefficients were utilised. Student t-test was used to test for differences in low back pain frequency in rowers with different years of experience. Pearson chi-square probability was used to see if Cybex training and stroke style make any difference in low back pain frequency. The significance level chosen was $p < 0.05$.

Results :

Table 2 shows isokinetic parameters of subjects (A) before, (B) immediately after and (C) 8 weeks after the isokinetic trunk flexion / extension exercise programme. There was no significant change immediately after training except for extension average power at 120 $degS^{-1}$ and extension peak torque at 120 $degS^{-1}$ and extension total work at 60 $degS^{-1}$. However, 8 weeks after Cybex training more significant changes in various isokinetic parameters were found in the training group at all the speeds tested.

Positive correlations were observed between low back pain level and water mileage; low back pain level and ergometer training; low back pain and number of races and / or time trial. (Table 3a)

Significant difference in low back pain frequency was found between subjects with different rowing experience. (Table 3b) Rowers with more years of rowing experience were shown to have lower incidence of low back pain. (figure 1)

Table 2: Isokinetic parameters of subjects (A) before, (B) immediately after and (C) 8 weeks after Cybex Training.

Table 2A

	Before Cybex Training (mean)		P (Sign of F)
	Training Group	Control Group	✐
Ext-Ave.Power 120 deg/sec (BWR, WATTS)	510	444	0.543
Ext-Ave.Power 90 deg/sec (BWR, WATTS)	407	385	0.770
Ext-Ave.Power 60 deg/sec (BWR, WATTS)	276	260	0.281
Ext-PT 120 deg/sec (Nm)	315	283	0.872
Ext-PT 90 deg/sec (Nm)	335	314	0.670
Ext-PT 60 deg/sec (Nm)	326	307	0.487
Ext-Total Work 120 deg/sec (BWR,J)	324	278	0.562
Ext-Total Work 90 deg/sec (BWR,J)	343	323	0.739
Ext-Total Work 60 deg/sec (BWR,J)	349	326	0.310
Flex-Ave.Power 120 deg/sec (BWR, WATTS)	395	352	0.985
Flex-Ave.Power 90 deg/sec (BWR, WATTS)	309	291	0.488
Flex-Ave.Power 60 deg/sec (BWR, WATTS)	213	206	0.225
Flex-PT 120 deg/sec (Nm)	260	245	0.888
Flex-PT 90 deg/sec (Nm)	253	234	0.661
Flex-PT 60 deg/sec (Nm)	252	242	0.331
Flex-Total Work 120 deg/sec (BWR,J)	246	220	0.916
Flex-Total Work 90 deg/sec (BWR,J)	264	247	0.517
Flex-Total Work 60 deg/sec (BWR,J)	273	261	0.278

★P<0.05, ✐ ANOVA analysis Simple Factorial (Factor:Sex & Group)

Table 2B

	Immediately after Cybex Training (mean)		P (Sign of F)
	Training Group	Control Group	✐
Ext-Ave.Power 120 deg/sec (BWR, WATTS)	503	436	0.026 ★
Ext-Ave.Power 90 deg/sec (BWR, WATTS)	394	356	0.118
Ext-Ave.Power 60 deg/sec (BWR, WATTS)	279	237	0.060
Ext-PT 120 deg/sec (Nm)	317	269	0.032 ★
Ext-PT 90 deg/sec (Nm)	333	280	0.093
Ext-PT 60 deg/sec (Nm)	335	275	0.063
Ext-Total Work 120 deg/sec (BWR,J)	319	274	0.019 ★
Ext-Total Work 90 deg/sec (BWR,J)	332	298	0.090
Ext-Total Work 60 deg/sec (BWR,J)	353	297	0.049 ★
Flex-Ave.Power 120 deg/sec (BWR, WATTS)	370	357	0.814
Flex-Ave.Power 90 deg/sec (BWR, WATTS)	292	274	0.614
Flex-Ave.Power 60 deg/sec (BWR, WATTS)	206	188	0.442
Flex-PT 120 deg/sec (Nm)	234	211	0.364
Flex-PT 90 deg/sec (Nm)	243	224	0.524
Flex-PT 60 deg/sec (Nm)	240	221	0.468
Flex-Total Work 120 deg/sec (BWR,J)	234	219	0.702
Flex-Total Work 90 deg/sec (BWR,J)	248	232	0.580
Flex-Total Work 60 deg/sec (BWR,J)	263	238	0.434

★P<0.05, ✐ ANOVA analysis Simple Factorial (Factor:Sex & Group)

Table 2C

	8 weeks after Cybex Training (mean)		P (Sign of F) ✐
	Training Group	Control Group	
Ext-Ave.Power 120 deg/sec (BWR, WATTS)	515	462	0.030 ★
Ext-Ave.Power 90 deg/sec (BWR, WATTS)	410	381	0.150
Ext-Ave.Power 60 deg/sec (BWR, WATTS)	288	257	0.025 ★
Ext-PT 120 deg/sec (Nm)	324	288	0.035 ★
Ext-PT 90 deg/sec (Nm)	344	308	0.045 ★
Ext-PT 60 deg/sec (Nm)	345	308	0.032 ★
Ext-Total Work 120 deg/sec (BWR,J)	325	290	0.024 ★
Ext-Total Work 90 deg/sec (BWR,J)	344	320	0.135
Ext-Total Work 60 deg/sec (BWR,J)	362	322	0.018 ★
Flex-Ave.Power 120 deg/sec (BWR, WATTS)	411	357	0.012 ★
Flex-Ave.Power 90 deg/sèc (BWR, WATTS)	318	287	0.157
Flex-Ave.Power 60 deg/sec (BWR, WATTS)	220	201	0.296
Flex-PT 120 deg/sec (Nm)	251	219	0.016 ★
Flex-PT 90 deg/sec (Nm)	258	229	0.044 ★
Flex-PT 60 deg/sec (Nm)	258	236	0.282
Flex-Total Work 120 deg/sec (BWR,J)	255	223	0.024 ★
Flex-Total Work 90 deg/sec (BWR,J)	268	242	0.155
Flex-Total Work 60 deg/sec (BWR,J)	279	254	0.257

★P<0.05, ✐ ANOVA analysis Simple Factorial (Factor:Sex & Group)

Table 3a: Pearson correlation coefficients of low back pain level & training pattern

Training Pattern	P
Water Training	0.000 ★
Ergometer	0.034 ★
No. of Races/time trial	0.004 ★

★P<0.05, all correlations are positive

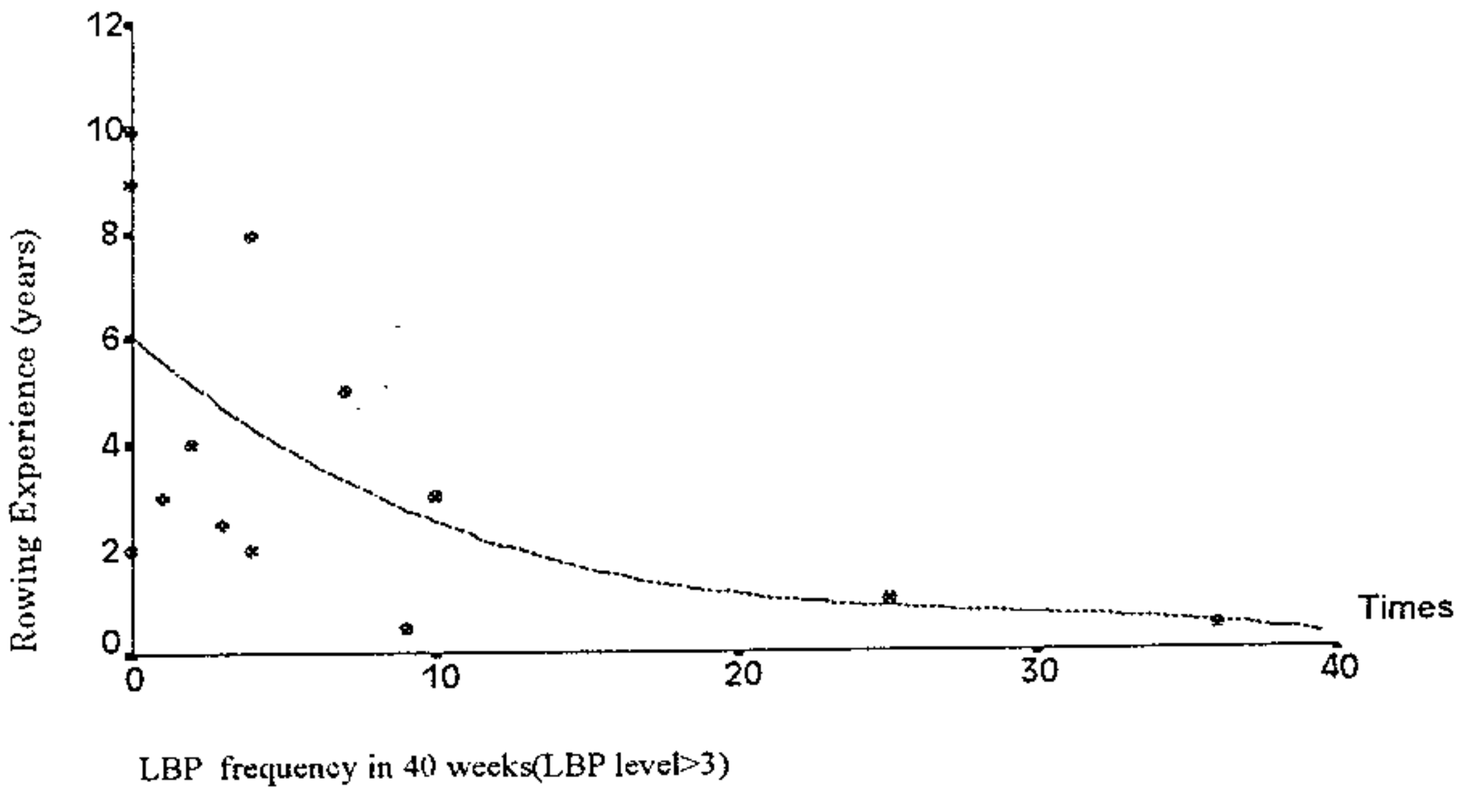


Figure 1: Relationship of LBP frequency and years of rowing experience

Subjects who underwent Cybex training also had a lower frequency in low back pain. Furthermore, Sweep rowers were found to have higher frequency of low back pain than scullers. (Table 3b)

Table 3b: Correlation of low back pain frequency, rowing experience, stroke style and Cybex training

	Analysis	P
Rowing Experience	T-Test	0.027 ★
Cybex Training	Phi coefficients	0.010 ★
Sculling or Rowing	Phi coefficients	0.038 ★

★P<0.05,

Figure 2 shows low back pain level of subjects before and after the isokinetic trunk flexion / extension training programme. Figure 3 shows the water mileage of subjects before and after the trunk flexion / extension training programme. From these two figures and the results of students' t-test, training group was shown to have lower low back pain level despite the general increase in water mileage after Cybex training. Pain level reminded low in the training group 15 weeks after training

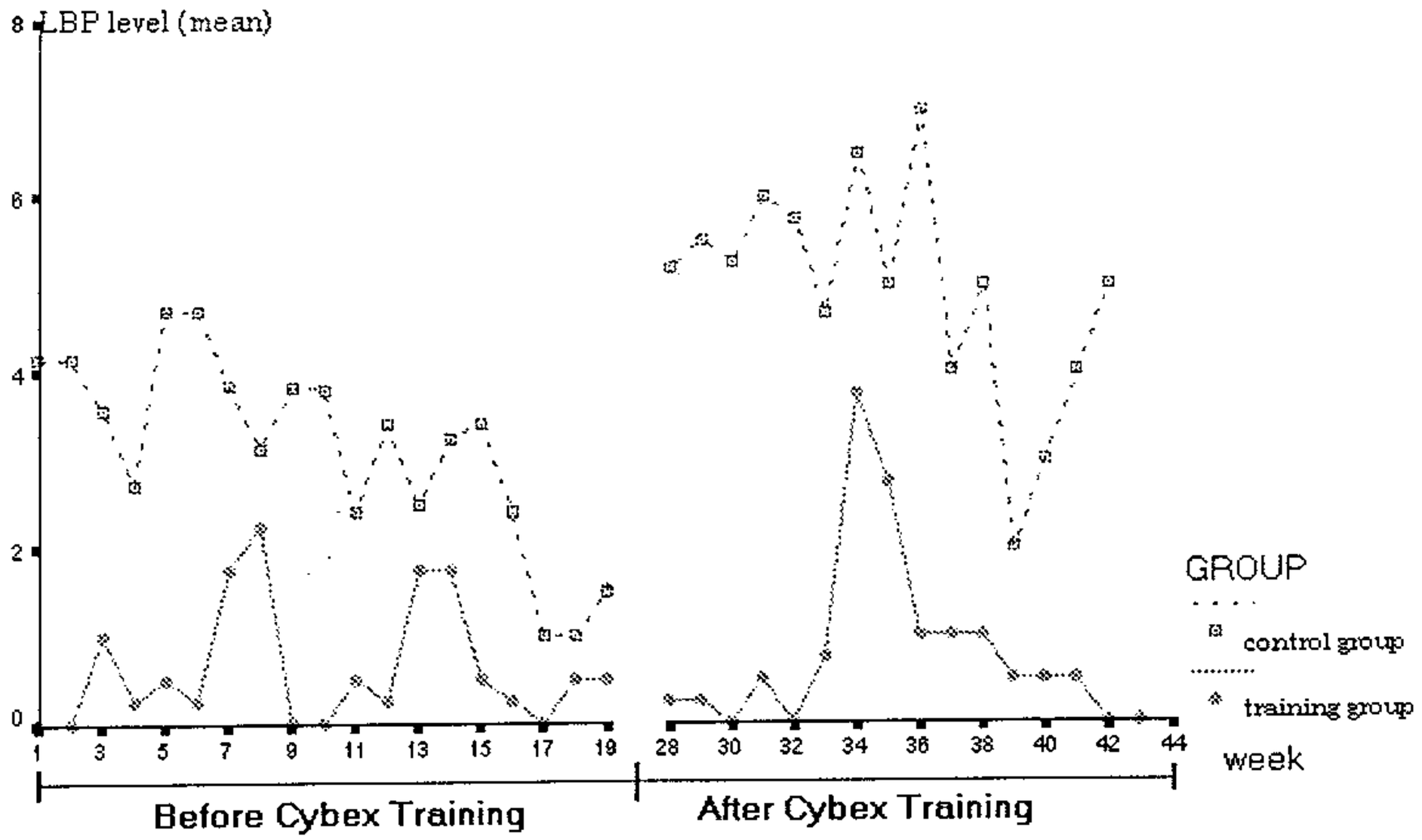


Figure 2: Low back pain level of subjects before and after isokinetic trunk flexion/extension training

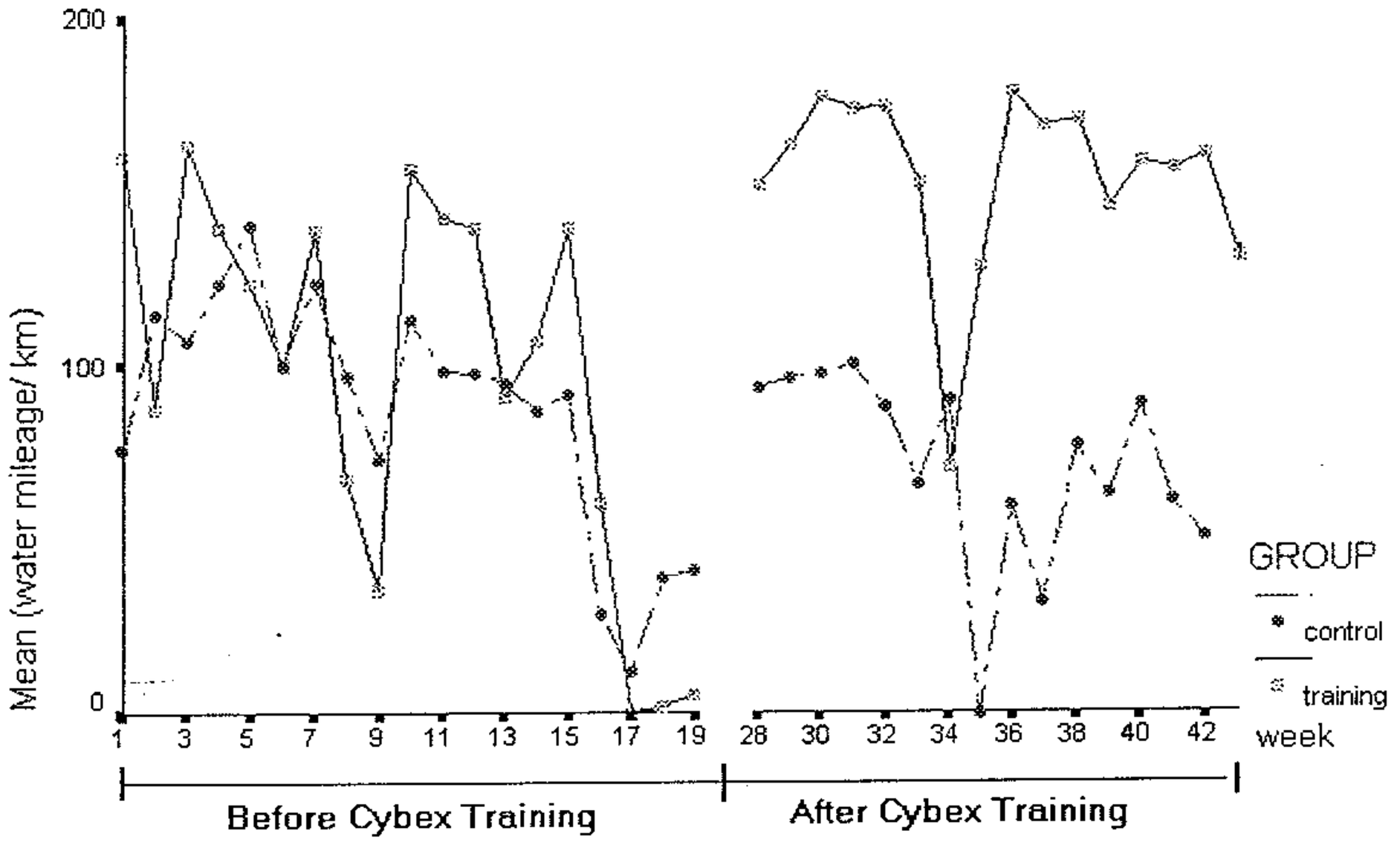


Figure 3: Water mileage (km) of subjects before and after isokinetic trunk flexion/extension training

Discussion

Results of the present investigation showed that low back pain level increased as water training mileage, number of ergometer training sessions and number of races / time trial increased. This corresponds with findings in studies that low back pain is associated with excessive back muscle fatigue. [41,42] Vicious circle develops when rowers keep on training with back pain when they can no longer maintain a correct posture during practice. It is essential that the concept of periodization is adopted when a year-a-round training programme is planned. Intensity and volume of workouts and the recovery periods should be manipulated appropriately so that the athletes can peak at the right time. Individual athlete might need to have the programme modified if signs of overtraining or undertraining are noticed since every athlete respond differently to the same intensity or volume of training. Tapering and proper recovery periods are as essential as training.

Recent evidence suggests that recovery from local muscle fatigue is influenced by a central nervous system fatigue that is independent of local blood flow. Use of diverting activities that involve non-fatigued muscles during recovery has been shown to increase performance during repeated work periods. [14] Perhaps swimming or even basketball should be introduced into the rowers' training programme regularly to enhance their recovery.

Results of this study also showed that rowers with less rowing experience were more vulnerable to low back pain. This can be easily explained by their poor postural control and the fact that their "rowing muscles" are not developed as much as their more experienced counterparts. Another phenomenon we observed was the longer the last low back pain injury was from the present moment the less the low back pain level was then. This might mean rowers with past low back injury had learnt their lessons and

had become more cautious and better conditioned after a period of rehabilitation.

Moreover, the incidence of low back pain was higher in sweep rowers than scullers in this study. The reason for this is probably the higher torsional loading on the sweep rowers' back as they reach at the catch, rotate their shoulders and back. This not only increases the stresses on the facet joints but also the annulus ligament and the muscles opposite the oar side. [47]

Since results showed that an isokinetic trunk flexion / extension programme was effective in reducing low back pain level and frequency among rowers, it is beneficial for rowers to have preseason isokinetic assessment. Rowers with little experience , sweep rowers and those who are shown to be weaker in the assessment are recommended to go through an isokinetic trunk flexion/extension training programme before the season begins.

Even though results demonstrated significant improvement in the strength, power & endurance of trunk extensors & flexors after isokinetic training, it is surprising to find that the improvement became more significant 8 weeks after training than immediately after. It might be due to the fact that the training group did in fact had higher on-water mileage than the control group during this 8 weeks of post isokinetic training. The other reason is a lack of rest period before the isokinetic assessment. The training group was in fact more tired immediately after training than the control group so the assessment could not reflect their real ability.

However, the fact that low back pain level and frequency was lower among trained rowers proved the isokinetic trunk flexion / extension training programme to be valuable. The mechanism might not only be due to better strength, power and endurance it might also be due to the

trunk extensors and flexors being more ready to co-contract during emergency situation and protect the spine better that way.

Results demonstrated that the efficacy could at least last for 8 weeks and pain level remained low 15 weeks after Cybex training. However, to maintain a low pain level and frequency condition, one is suggested to have regular sessions all year-around. The isokinetic trunk flexion / extension training can be done once a week as a part of the routine rowing training programme so that training effect can be maintained. However, further investigation is needed for the evaluation of long term benefits of the programme. From the questionnaires of this study we found that 17% of the training sessions had to be stopped or altered due to low back pain. If the incidence of low back pain can be prevented, training would no doubt become more effective and the athletes' performance would be improved.

Above all, early treatment is important once injury has occurred. Very often, elite athletes who are highly motivated and dedicated can be very reluctant to admit that they have been injured and do not want to decrease their training intensity or volume even though they are in pain. Sport physiotherapists, sport scientists, sport psychologists, coaches and sport medicine specialists all play major role in educating athletes to face their injuries positively and seek appropriate treatment as early as possible so that their future performance and achievement would not be deterred.

References

1 Addison R, Schultz A

Trunk strengths in patients seeking hospitalization for chroic low back disorders

SPINE 5(6):539-544, 1980

2 Ambrosius FM, Kremer AM, Bartz SR, Herkner PB,

A preliminary comparsion of isokinetic data among back-injured surgical and nonsurgical patients, and the effect of a functional restoration program on their ability to return to work

Isokinetics and exercise science 4(1):34-39, 1994

3 Andersson E, Sward L, Thorstensson A

Trunk Muscle strength in athletes

Medicine and science in sports and exercise 20(6):587-593, 1988

4 Barnes WS

The relationship of motor-unit activation to isokinetic muscular contraction at different contractile velocities

Physical therapy 60(9):1152-1158, 1980

5 Bell GJ, Petersen SR, Quinney HA, Wenger HA

The effect of velocity- specific strength training on peak torque and anaerobic rowing power

Journal of sports science 7:205-214, 1989

6 Boland AI, Hosen TM

Rowing and Sculling and the older athlete

Clinics in sports medicine 10(2):245-256, 1991

7 Brady S, Mayer T, Gatchel RJ

Physical progress and residual impairment Quantification after functional restoration, Part II: isokinetic trunk strength

SPINE 19(4):395-400, 1994

8 Bruknes P, Khan K

Clinical sports medicine

McGraw-Hill Book Company, Sydney, 1993 P266-267

9 Byl NN, Sadowsky HS,

Intersite reliability of repeated isokinetic measurements: Cybex back systems including trunk rotation, trunk extension-flexion, and liftask

Isokinetics and exercise science 3(3):139-147, 1993

10 Curtis LC, Mayer T, Gatchel RJ

Physical progress and residual impairment Quantification after functional restoration. Part III: isokinetic and isoinertial lifting capacity

SPINE 19(4):400-405, 1994

11 Edgar M

Rowing injury

Sportcare journal 2(1):32-35, 1995

12 Farfan HF, Cossette JW, Robertson GH, Wells RV, Kraus H

The effects of torsion on the lumbar intervertebral joints: the role of torsion in the production of disc degeneration

The journal of bone and joint surgery 52-A(3):468-497, 1970

13 Fenety A, Kumar S

Isokinetic trunk strength and lumbosacral range of motion in elite female field hockey players reporting low back pain

JOSPT 16(3):129-135, 1992

14 Fisher AG, Jensen CR

Scienific bacis of athletic conditioning

Lea & Febiger, Philedclphia London, 1990, P148-150.

15 Flint MM

Effect of increasing back and abdominal muscle strength on low back pain

The research quarterly 29(2):161-171,1992

16 Foster DN, Fulton MN

Back pain and the exercise prescription

Clinics in sports medicine 10(1):197-209, 1991

17 Gould III JA (editor)

Orthopaedic and sports physical therapy

The C.V. Mosby Company, 1985

18 Grieve GP

Common vertebral joint problems

Churchill Livingstone Inc, London, 1981

19 Hagerman FC

Applied physiology of rowing

Sports Medicine 1(4):303-326 1984

20 Hass M, Jacobs GE, Raphael R, Petzing K

Low back pain outcome measurement assessment in chiropractic teaching clinics: responsiveness and applicability of two functional disability questionnaires

Journal of manipulative and physiological therapeutics 18(2):79-87, 1995

21 Hoffman RM, Turner JA, Cherkin DC, Deyo RA, Herron LD

Therapeutic trials for low back pain

SPINE 19(18s):2068s-2075s, 1994

22 Howell DW

Musculoskeletal profile and incidence of musculoskeletal injuries in lightweight women rowers

The American journal of sports medicine 12(4):278-282, 1984

23 Klein AB, Snyder-Mackler L, Roy SH, DeLuca CJ

Comparison of spinal mobility and isometric trunk extensor forces with electromyographic spectral analysis in identifying low back pain

Physical therapy 71(6):445-454, 1991

24 Koes BW, Bouter LM, Mameren H van, Essers AH, Verstegen GMJR, Hofhuizen DM, H

Randomised clinical trial of manipulative therapy and physiotherapy for persistent back and neck complaints: results of one year follow up

BMJ 304:601-605, 1992

25 Koes BW, Bouter LM, Mameren H van, Essers AHM, Verstegen GJMG, Hofhuizen DM,

A randomized clinical trial of manual therapy and physiotherapy for persistent back and neck complaints: subgroup analysis and relationship between outcome measures

Journal of manipulative and physiological therapeutics 16(4):211-219, 1993

26 Kohles S, Barnes D, Gatchel RJ, Mayer T

Improved physical performance outcomes after functional restoration treatment in patients with chronic low back pain (early versus recent training results)

SPINE 15(12):1320-1324, 1990

27 Langrana NA, Lee CK

Isokinetic evaluation of trunk muscles

SPINE 9(2):171-175, 1984

28 Langrana NA, Lee CK, Alexander H, Mayott CW

Quantitative assessment of back strength using isokinetic testing

SPINE 9(3):287-290, 1984

29 Manniche C, Asmussen K, Lauritsen B, Vinterberg H, Kreiner S, Jordan A

Low back pain rating scale: validation of a tool for assessment of low back pain

Pain 57:317-326, 1994

30 Mayer T, Tabor J, Bovasso E, Gatchel RJ
Physical progress and residual impairment Quantification after functional restoration, Part I: lumbar mobility
SPINE 19(4):389-394, 1994

31 Mcneill T, Warwick D, Andersson G, Schultz A
Trunk strengths in attempted flexion, extension, and lateral bending in healthy subjects and patients with low back disorders
SPINE 5(6):529-538, 1980

32 Melzack R
The McGill pain questionnaire: major properties and scoring methods
Pain 1:277-299, 1975

33 Morris JM, Lucas DB, Bresler B,
Role of the trunk in stability of the spine
The journal of bone and joint surgery 43-A(3)327-351, 1991

34 Motto SG
Mechanical back pain in rowers
Physiotherapy in sport XIX(5):16-17, 1994

35 Nachemson A
Newest knowledge of low back pain
Clinical orthopaedics and related research 279:8-20, 1992

36 Nachemson A, Lindh M
Measurement of abdominal and back muscle strength with and without low back pain
Scand J Rehab Med 1:60-65, 1969

37 Nachemson AL
The Lumbar spine, an orthopaedic challenge
Spine 1:59, 1976

38 Omino K, Hayashi Y
Perparation of dynamic posture and occurrence of low back pain
Ergonomics 35:693-707, 1992

39 Pope MH, Phillips RB, Haugh LD, Chang YJ, MacDonald L, Haldeman S
A prospective randomized three-week trial of spinal manipulation, transcutaneous muscle stimulation, massage and corset in the treatment of subacute low back pain
SPINE 19(22):2571-2577, 1994

40 Rodriguez RJ, Rogriguez RB, Cook SD, Sandborn PM
Electromyographic analysis of rowing stroke biomechanics
The journal of sports medicine and physical fitness 30(1):103-108, 1990

41 Roy SH, De Luca CJ, Casvant DA
Lumbar muscle fatigue and chronic lower back pain
SPINE 14:992-1001, 1989

42 Roy SH, DeLuca CJ, Snyder-Mackler L, Emley MS, Crenshaw RL, Lyons JP
Fatigue, recovery, and low back pain in varsity rowers
Medinine and science in sports and exercise 22(4):463-469, 1990

43 Sanderson B, Martindale W
Towards optimizing rowing technique
medicine and science in sports and exercise 18(4):454-468, 1986

44 Shernan WM, Pearson DR, Plyley MJ, Costill DL, Habansky AJ, Vogelgesang DA
Isokinetic rehabilitation after surgery

The American journal of sports medicine 10:115-161, 1992

45 Smidt G, Herring T, Amundsen L, Rogers M, Russell A, Lehmann T

Assessment of abdominal and back extensor function, A quantitative approach and results for chronic low-back patients

SPINE 8(2(:211-219, 1983

46 Snyder-Mackler L

Rehabilitation of the athlete with low back pain dysfunction

Clinics in sports medicine 8(4):717-729, 1989

47 Soghikian GW

Common injuries and how to treat them: back pain

American rowing 37-43 Mar/Apr, 1995

48 Suzuki N, Endo S

A quantitative study of trunk muscle strength and fatigability in the low back pain syndrome

SPINE 8(1):69-76, 1983

49 Thomas P

Managing rowing backs

The practitioner 233(1465):446-447, 1989

50 Thompson NN, Gould JA, Davies GJ, Ross DE, Price S

Descriptive Measures of isokinetic trunk testing

JOSPT 7(2):43-49, 1985

51 Timm KE

Case studies: use of Cybex trunk extension flexion unit in the rehabilitation on back patients

JOSPT 8(12):578-581, 1987

52 Timm KE,

Management of the chronic low back pain patient: A retrospective analysis of different treatment approaches

Isokinetics and exercise science 1(1):44-48, 1991

53 Timm KE, Malone TR

Back injuries and rehabilitation

Sports injury management 2(3):11-16, 1989

54 Triano JJ, Mcgregor M, Cramer GD, Emde DL

A comparison of outcome measures for use with back pain patients: results of a feasibility study

Journal of manipulative and physiological therapeutics 16(2):67-73, 1993

55 Tumilty DM

Prevention of low back pain in rowers part 2A: Weight training: the squat

Excel 4(2):3-5, 1987

56 Tumilty DM

Prevention of low back pain in rowers part 2b: Weight training: the power clean

Excel 4(3):3-5, 1987

57 Waddell G

A new clinical model for the treatment of low back pain

SPINE 12(7):634-644, 1987

58 Wajswelner H

Prevention of low back pain in rowers part 1:Stretching and strengthening

Excel 4(1):10, 1987

Appendix 1

Lower Back Condition of Hong Kong Elite Rowers (1995) Before Isokinetic Trunk Exercise Programme

姓名 Name :_____ 性別 Sex :_____

出生日期 Date of Birth :_____年/YY _____月/MM _____日/DD

現時 Present: (a) 單槳 Rowing
(b) 雙槳 Sculling
(c) 單槳及雙槳 Rowing & Sculling

* 過去如有改變，請註明日期:_____年 _____月，
由 (a) 單槳轉爲雙槳，或
(b) 雙槳轉爲單槳，或
(c) 其他 _____

* Please specify when, if you have changed from one to another: ____YY___MM,
(a) from Rowing to Sculling, or
(b) from Sculling to Rowing, or
(c) others _____

划艇經驗（年數）
Rowing Experience (in years) :_____

過去腰部曾否試過嚴重受傷? 曾 / 否
Any major lower back injury in the past? Yes / No

如有，什麼事?
If yes, please specify. _____

何時? _____年 _____月 _____日
When? _____YY _____MM _____DD

該次腰部嚴重受傷之後，有沒有因此而改變/停止訓練? 有 / 沒有
如有， (a) 改變 _____ 星期，或
(b) 停止 _____ 星期
After the major lower back injury, did you have to alter/stop training? Yes / No
If yes, (a) alter for _____ week(s), or
(b) stop for _____ week(s)

該次嚴重腰傷往後有否復發?
Has the major lower back injury ever recurred since then?
(1) 從未 never (2) 偶然 occasionally (3) 有時 sometimes (4) 經常 always

Appendix 2

** 請於每星期日下午填寫此記錄 **

**** Please fill this in every Sunday afternoon ****

日期 Date: _____

過去一週之訓練記錄 **Last Week's Training Record**

水上里數 Water mileage: _____ 公里/km

拉機時間及次數 Ergometer: _____ 分鐘/minute(s) _____ 次數/time(s)

舉重次數 Weight training: _____ 次數/session(s)

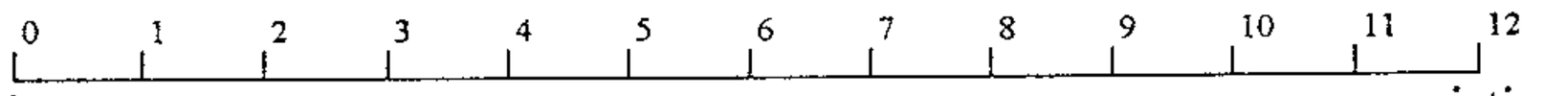
計時 Time trial: _____ 次數/time(s)

比賽次數 Number of races: _____ 次數/time(s)

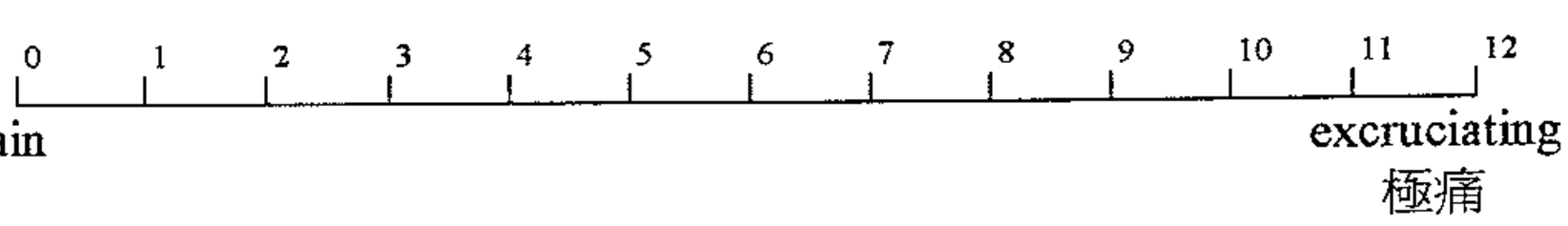
其他 others: _____

過去一週之腰痛紀錄 **Last Week's Low Back Pain Record**

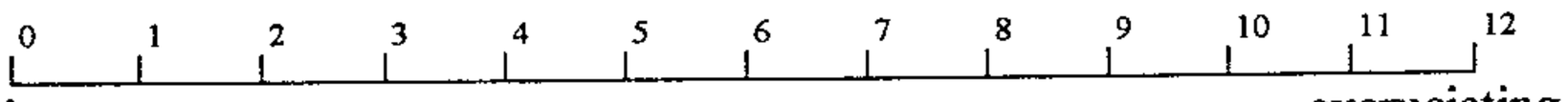
1. 過去一週大部份時間的痛楚程度
   Describe your constant pain level in the last week.



2. 過去一週最厲害的痛楚程度
   Describe your pain at its worst level in the last week.



3. 過去一週最輕的痛楚程度
   Describe your pain at its least level in the last week.



4. 在過去一週你有多少次因爲腰痛去看物理治療師?
How many times did you see a physiotherapist for low back pain last week?

有 Yes _____ 次 time(s) / 否 No

5. 除了物理治療，在過去一週你有否因爲腰痛去尋求其他治療?
Did you receive other forms of treatment other than physiotherapy last week?

有 Yes / 否 No

如有，什麼治療? If yes, please specify. _____
多少次? How many times? _____

6. 過去一週你有否因爲腰痛而改變/停止訓練?
Did you alter / stop training due to low back pain last week?

有 Yes / 否 No

如有，什麼? If yes, what?

(a) 水上里數 Water mileage : 改變 altered _____ 次/time(s),
停止 stopped _____ 次/time(s)

(b) 拉機時間及次數 Ergometer : 改變 altered _____ 次/time(s),
停止 stopped _____ 次/time(s)

(c) 舉重次數 Weight training : 改變 altered _____ 次/time(s),
停止 stopped _____ 次/time(s)

(d) 計時 Time trial : 改變 altered _____ 次/time(s),
停止 stopped _____ 次/time(s)

(e) 比賽次數 Number of races : 改變 altered _____ 次/time(s),
停止 stopped _____ 次/time(s)

(f) 其他 others : 改變 altered _____ 次/time(s),
停止 stopped _____ 次/time(s)