THE MOBILISING EFFECTS OF REPEATED MEASUREMENT ON HIP FLEXION*

J. ATHA, Ph.D., M.A., D.P.E. & D. W. WHEATLEY, B.Sc.

Human Sciences Dept., University of Loughborough

Introduction

A test of flexibility, so widely used that it deserves to be called the classical measure, is hip flexion. It has featured in a variety of guises as the toe-touch test (Weber and Kraus, 1949; Buxton, 1957; Larson, 1974) the sit and reach test (Wells and Dillon, 1952), the femoral trunk angle (Troup, Hood and Chapman, 1968) and supine leg lift (Tanigawa, 1972). Harris (1969) reports on its high reliability, Broer and Galles (1958) on its independence of length differences between the upper and lower body segments, and Wells and Dillon (1952) and Matthews, Shaw and Bohnen (1957) on the high correlation between its different forms. The relative role of hamstring extensibility and spinal mobility have been evaluated by Troup, Hood and Chapman (1968) and by Fieldman (1968) and both agree that spinal mobility is secondary to hamstring extensibility in determining the range of movement measured.

From the foregoing it might be concluded that hip flexion would make a suitable criterion measure by which to judge the effectiveness of different methods of increasing joint mobility. However, when one is seeking to measure change any tendency for the baseline measure to vary with successive observations must be considered a disadvantage, and Fieldman (1966) after comparing two successive observations in the course of a study of exercise hinted that this tendency might exist. This small study was therefore undertaken to determine whether and to what extent mobilising effects arise from mobility measurements. It was hoped that if any tendency were found for such changes to occur then they could be taken into account in subsequent studies by the adoption of suitable stabilising procedures of warm-up and practice.

Method

The maximum range of hip flexion was measured twenty times from a cold start, i.e. ten times at one minute intervals on each of two days, in ten male subjects.

The hip flexion test used was a modified sit and reach test in which the subject sat on a bench with feet flat against a vertical foot rest. Across the bottom of the footrest was fastened a 2 cm thick "heel" which ensured that the feet remained in a slightly plantar flexed position that released the triceps surae and sciatic nerve from undue stretch. The legs were held straight and together, and were strapped down firmly to the bench with a nylon belt. From this position the subject reached forward steadily with his finger tips to beyond his toes, pushing a curser along a metrically calibrated horizontal surface positioned across the top of the footrest 33 cm above the bench.

Hip flexion, i.e. the maximum reach that could be held momentarily, was measured from an arbitrary zero 20 cm short of the toes, to the nearest 0.5 cm. "Bounce maxima" using the body's momentum in sudden flexion, were not allowed.

All measurements were recorded, no preliminary trials were permitted. The belt was unfastened between trials as the subject rested. Comfortably warm environmental conditions and constant modest levels of motivation — in so far as it was possible to ensure them — were maintained throughout.

Diurnal variations (Wright and Plunkett, 1962) were avoided by re-testing at the same time on each day.

Results

The means and standard deviations of the measurements of hip flexion reach, in centimetres, for all subjects, partitioned by day and by trial are presented in Table I.

Table I: Hip flexion test. Means and standard deviations of ten measurements on two days for ten subjects

Measurement	DAY 1 X	(S.D.)	DAY 2 X	(S.D.)
1	24.7	(6.0)	25.1	(5.7)
2	26.1	(5.1)	26.9	(6.0)
3	27.7	(5.3)	28.2	(5.4)
4	27.3	(5.2)	29.0	(6.0)
5	28.2	(5.1)	28.7	(5.0)
6	28.4	(5.2)	29.1	(4.9)
7	29.0	(5.1)	29.5	(5.5)
8	28.9	(5.1)	28.8	(4.7)
9	29.3	(5.6)	29.7	(5.1)
10	29.2	(6.0)	29.6	(5.4)
X̄	27.9	(5.9)	28.5	(5.9)

These figures may be interpreted more meaningfully, perhaps, if they are adjusted by subtracting 20 cm to allow for the difference between the line of the toes and the arbitrary zero of the scale of measurement adopted.

The reliability of the raw data was determined by calculating Pearson product moment correlation coefficients between all trials on both days. Normally the more appropriate method is to calculate the intra-class correlation coefficient using the analysis of variance (Hoyt, 1941) but where trend effects are present — and such trend effects were found — the procedure is not appropriate (Liba, 1962); hence the somewhat inconvenient method adopted.

All reliability coefficients on Day 1 lay between r = 0.90 and r = 0.99. On Day 2 they were initially lower, i.e. until after the first four trials when they rose to lie between r = 0.87 and r = 0.97. It is therefore assumed that the measurements on which the rest of this analysis is based are reliable.

The results given in Table I show that the average reach of all subjects on both days was 4.9 cm beyond the toes at the start of the ten measurements but that at the end this had increased to 9.4 cm. The average changes recorded between the first and last trials on both days, viz. 4.5 cm, were identical.

The patterns of change on both days are also very similar, larger increases being recorded between the earlier trials than subsequently. This pattern is illustrated in Figure 1, from which it may be seen that on each day there was a systematic and progressive tendency for the range of hip flexion to increase with each measurement.
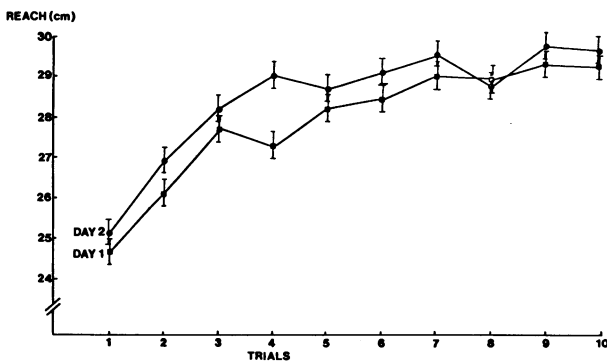

Figure 1: Hip flexion mobility changes occurring over ten successive measurements on each of two days.

The significance of these findings was evaluated using a repeated measures analysis of variance, the results of which are summarised in Table II.

Table II: Summary of the analysis of variance of the effects of successive trials on hip flexion mobility.

Source of Variance	d.f.	Sums of Squares	Mean Squares	Fobs
Between subjects (S)	9	3047.04	—	—
Between trials (T)	9	377.89	42.00	10.76**
(Linear trend	1)	299.19	) 299.19'	76.72**)
{ Quadratic trend	1 {	60.39	{ 60.39	{ 15.49** {
(Residual trend	16)	27.39	) 1.71,	) <1.0)
Between Days	1	15.96	15.96	<1.0
S x T interaction	81	315.55	3.90	1.63*
S x D interaction	9	133.43	24.83	10.35**
T x D interaction	9	9.08	1.01	<1.0
Residual error	81	194.15	2.40	—
Total	199	6183.10	—	

* = significant at 5% level
** = significant at 1% level

The highly significant F-ratio (10.76; alpha <0.01) associated with the main effects for trials permits the conclusion that the differences referred to above between trials are not due to chance. As this trial effect seemed to be a progressive one, orthogonal polynomials were used to partition and test for the components of trend. The variances associated with the two trends of interest, viz linear and quadratic, are listed in Table II, and an overall test made for all higher order components.

The outstandingly significant linear trend shown (F = 76.72) together with almost equally significant quadratic trend, accounts for almost the entire variance between the different trials. It is concluded without reservation that the act of measuring hip flexion does increase the mobility of the joint, and that this change is a simple function of the frequency of measurement.

Further examination of the Anova summary table shows that the results obtained on Day 1 are not significantly different from those on Day 2. However in view of the consistent, though slight differences between similar trials on Days 1 and 2 the possibility that some transfer of effects occurs between days cannot be ruled out, and judgement is reserved about the presence of a Day effect.

No such reservations need to be kept about the significance of the Subject-by-Days interaction (F = 10.53, alpha <0.01), a finding presaged by the low reliability coefficients found on the second day between the first few trials. Such individual variability is to be expected, however, and though its causes may be of fundamental interest generally, its presence here merely emphasises the importance of establishing suitably standardised

warm-up procedures for reducing such variability to a minimum while confirming the need for collecting an adequate sample of subjects to permit the correct determining of treatment effects.

Fortunately the above findings themselves suggest the type of warm-up needed. If most of the changes occur over the first four trials, and if most of the variability within individual scores are confined to those same trials, then merely by using a four trial practice before a three trial test, and selecting the best of the three trials as the mobility baseline — which would allow for individual differences in achieving a constant baseline — an appropriate warm-up procedure is established.

To estimate the effect the adoption of such a minimum standardised warm-up would have had on the foregoing results difference scores were calculated for each subject between the first (cold start) trial on Day 1 and the best of the 5th, 6th and 7th trials. The mean and standard deviation calculated for these difference scores were $\bar{X}$ = 4.9 cm, S.D. = 2.1 cm. As this mean is only 0.4 cm different from the overall average change between the first and last trials it may be seen that little advantage is to be gained by increasing either the length of the warm-up or the number of test trials.

Harris (1969) in her review reports that "... most investigators ... (into methods of improving mobility) use no warm-up activities before collecting data". The findings of this study throw serious doubt upon the wisdom of this practice. Using a cold start pre-treatment measurement as a baseline from which to judge the effectiveness of a mobilising technique must lead to the spurious elevation of the observed effects. Given such a baseline the mobility changes observed should be considered to be perched upon a pedestal of gains immediately available to the experimenter merely by the execution of the odd good stretch. Consequently any mobilising technique purporting to be effective should be expected to produce a mobility change significantly greater than this.

Conclusion

The following conclusions are drawn:
a) the act of measuring joint mobility increases mobility,
b) the magnitude of the effect is a linear and quadratic function of the frequency of measurement which eventually levels off to a stable baseline,
c) there is a slight statistically non-significant but consistent tendency for these mobilising effects to persist for more than one day.

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